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THE EFFECTS OF THORIUM DIOXIDE SOL (THOROTRAST)[1] ON THE HUMAN LIVER[2]

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INTRODUCTION

THE usefulness of thorium dioxide sol in the roentgen diagnosis of diseases of the liver and spleen has been well demonstrated by numerous articles in the recent medical literature (23, 24, 15, 16, 7, 33, 13). Its utility, however, has been greatly restricted by the fear, which has been so frequently expressed, that ill effects may follow its injection. The dangers associated with the use of this substance have been abundantly described and numerous conflicting opinions have been presented regarding the justification for its employment. While the original protagonists for the utilization of this colloidal suspension of thorium dioxide (thorotrast), Radt (24) and Kadrnka (16), apparently are satisfied that it presents no real danger; others, such as Anders and Leitner (1), Büchner (2), Cooke (4), Hanke (8), Shute and Davis (29), Pohle and Ritchie (21) and others, criticize the use of this material most emphatically. Naegeli and Lauche (20) take a middle ground, while numerous other authors, such as Ravenna (26), Tripoli (30), Tripoli, Haam and Lehman (32), Irwin (14), Yater and Otell (33), Ericksen and Rigler (7), Hirsch and Morton (13), and others believe there is relatively little harm produced by this procedure, if the opaque substance is given in moderate doses.

The dangers inherent in this method of roentgen diagnosis may be divided into a number of categories. There are, first, the usual accompaniments to the intravenous injection of any substance, particularly a colloid. The immediate effects, such as rise in temperature, slight nausea, flushing, etc., have been previously described (7) and are of no particular consequence. The hemoclastic effect of the injection of colloids has been emphasized by Shih and Jung (28). Our experience, and that of many others, would seem to indicate that these hemoclastic crises, which Stewart, Einhorn, and Illick (27) encountered, are due either to unstable or poorly prepared material or to the use of enormous doses. As stated in a previous publication (7), we have had only one such experience and this was later proved to be due to a faulty preparation. One case of death from anuria—a possible sequence to injection of a colloid—has been reported (34), but in this case a transfusion

[1] The preparation used in this work was the commercial product "Thorotrast" made by the Heyden Chemical Corporation.

[2] Presented as an exhibit at the Twentieth Annual Meeting of the Radiological Society of North America, at Memphis, Tenn., Dec. 3–7, 1934.

had also been given, so there is serious doubt as to the culpability of the thorium preparation. Some transient anuria, however, has occurred in dogs after the injection of thorium dioxide sol. We have had no such experience either in animals or amongst the 175 patients upon whom we are here reporting.

The possibility of rupture of the spleen has been considered because of the report of Büngeler and Krautweig (3), who gave a fairly large dose of thorium dioxide sol to a patient with severe reticulo-endotheliosis. A massively enlarged, very soft spleen was present and rupture occurred, with a fatality resulting. They consider massive enlargements of the spleen and reticulo-endotheliosis contra-indications to the use of this method.

The production of a partial or complete obstruction of the reticulo-endothelial system by the introduction of colloidal material has been frequently considered one of the objections to the use of thorium dioxide sol. It has been repeatedly demonstrated, however, that blockage of these phagocytic cells is virtually impossible. Furthermore, it has been shown that the function of these cells is so selective that they will continue to phagocytose foreign substances of a different type, even though they have already ingested large amounts of another substance. The experiments of Ravenna (26) indicate clearly that the normal function of the reticulo-endothelial cells of the liver is maintained in spite of the introduction of large quantities of colloidal thorium. Held (12) was unable to demonstrate any definite change in the immunity of animals after injection of this substance.

None of the preceding deleterious effects are sufficiently frequent or of any great importance in the consideration of the general use of thorium dioxide sol for the roentgen examination of the liver and spleen. Of much greater importance is the fact, now generally admitted, that elimination of this substance from the liver and spleen, if it occurs at all, is exceedingly slow, the material remaining in the body at least for many years. Some evidence of the nature of this slight elimination has been advanced by Kadrnka (16), Naegli and Lauche (20), Leipert (17), and others. The introduction of a foreign body of this nature, which may remain permanently in the body, is fraught with danger to the organ in which it is deposited. It may produce tissue changes as a result either of a specific toxic effect, as a simple foreign body reaction, or from the slight radio-activity which it possesses.

The matter of the radio-activity of this substance was originally a source of great concern (5, 7), but of late this has not been stressed to any great extent. The dosage has been reduced—we are now using only 0.6 c.c. of the commercial preparation thorotrast (Heyden) per kilo of body weight—to a point at which the total maximum radio-activity appears to be well below the usually accepted tolerance quantity. In an experience of over four and one-half years, no effects which could definitely be assigned to the radiations of thorium have as yet been reported. It has been pointed out that it is barely possible that the histologic changes observed in the liver, spleen, and lymph nodes may be related to the alpha particles given off by the decay of the various components of this colloidal suspension, but this conclusion seems highly improbable. The nature of these changes is not at all that of radiation necrosis (9), and there are none of the other effects which might be expected. Obviously, it will be impossible to settle this point until observations have been continued for a longer period of years, and for the present this question must be left in abeyance.

By far the most important deleterious effect which has been reported is concerned with the histologic changes which occur in the liver, spleen, and lymph nodes. These have been observed chiefly in experimental animals and, in large part, unfortunately, after the introduction of very large or massive doses. The demonstration of severe disintegration of the liver after the injection of a dose approximately ten times the normal, while it may be of importance in determining the limitations of the dosage,

can hardly be considered a controlling force in the judgment of the dangers of this substance when given in reasonable amounts. On the other hand, definite changes have been reported (10, 19, 21) in animals even with doses as small as one and one-half to three times the normal. While the regenerative powers of the human liver are well known, nevertheless, one hesitates to produce any damage merely for purposes of diagnosis. It is these two factors particularly, *i.e.*, the lack of elimination of the material and the production of necrosis, cloudy swelling, and atrophy in the liver, spleen, and lymph nodes, which have prevented the widespread utilization of this method of roentgen diagnosis.

Because there are differences in the behavior of animals and man toward such substances, and because in experimental work larger doses than normal have been used, we have felt that a careful study of clinical cases would add to our knowledge of the dangers of the employment of thorium dioxide sol to render the liver and spleen opaque to roentgen rays.

Relatively few studies have been made on the liver of humans after the injection of this material. Whitaker, Davie, and Murgatroyd (35) reported on three cases examined postmortem. Tripoli (30), Hirsch and Morton (13), Ericksen and Rigler (7), Kadrnka (16), Popper and Klein (22), Randerath (25), and others have also reported the evidences of histologic changes as observed at autopsy. In none of these reports has there been any alarming evidences such as have been observed in animals by Shute and Davis (29), Cooke (4), Pohle and Ritchie (21), and others, although some definite changes were demonstrated.

CLINICAL STUDIES

We have had the opportunity of examining 175 patients with thorium dioxide sol in the past three and one-half years. The first 80 cases in this series have already been reported (7), and the present report is intended to demonstrate, insofar as possible, the eventual results which could be observed in these patients.

The type of case which was subjected to this examination is indicated in Table I. It should be noted that the patients were almost all suffering from very grave diseases, largely malignant tumors, with or without known metastases. The high incidence of liver metastases, found on roentgen examination by this method, is shown.

TABLE I.—TYPE OF CASE IN WHICH THORIUM DIOXIDE SOL (THOROTRAST) EXAMINATION WAS USED AND INCIDENCE OF POSITIVE FINDINGS

Primary Diagnosis	No. of cases	Hepatolienography Positive	Negative
Carcinoma of stomach	60	17	43
Carcinoma of colon	15	4	11
Carcinoma of rectum	21	10	11
Carcinoma of breast	12	6	6
Carcinoma, miscellaneous	27	14	13
Malignant tumors, miscellaneous	9	1	8
Leukemia	2	2	0
Lymphogranuloma	4	2	2
Actinomycosis	2	1	1
Cirrhosis of liver	5	4	1
Miscellaneous diseases	18	5	13
Total	175	66	109

In Table II, the diagnostic accuracy of this procedure, as demonstrated by surgical or postmortem exploration, is tabulated. In spite of a relative lack of experience with the method it can be noted that the accuracy is relatively high. The three positive errors were all due to misinterpretation of normal structures, such as the vascular channels of the liver, the gall-bladder fossa, and the areas of apparently lessened density between the anterior ribs. The negative errors are really not as frequent as appears from the table. In two cases, for example, the carcinomatous metastases were microscopic in size and could not be detected even at autopsy by gross examination. In another case only one very small metastasis was found, while in still another only two small nodules were present. From the diagnostic standpoint, our experience on the whole was very satisfactory.

The present status of the patients to whom thorium dioxide sol was given may also best be demonstrated in tabular form

TABLE II.—DIAGNOSTIC ACCURACY OF HEPATOLIENOGRAPHY

Proved cases	74	Correct 65	Incorrect 9
By autopsy	35		
By operation	39		
Roentgen diagnosis positive		Correct 16	Incorrect 3
Roentgen diagnosis negative		Correct 49	Incorrect 6

(Table III). As might be expected, the vast majority have succumbed. Many of them were almost moribund at the time of the injection. Many underwent very radical resections of the stomach, colon, or rectum and did not survive the surgical procedure. Many already had extensive metastases at the time of the examination or developed them shortly after. It is our well-considered judgment that the mortality in this group is no greater than would ordinarily be expected with this type of patient (Table I). In support of this it may be observed that most of the patients with relatively minor diseases such as cholelithiasis, enlarged spleen of undetermined origin, or intra-abdominal masses of benign nature, to whom this material was given, either in error or in the earliest period of our experience, are still living and well.

TABLE III.—EVENTUAL OUTCOME OF 175 PATIENTS RECEIVING THORIUM DIOXIDE SOL (THOROTRAST)

Known living and apparently unaffected		43
Cases followed less than 12 months	15	
Cases followed less than 18 months	5	
Cases followed less than 24 months	11	
Cases followed less than 30 months	8	
Cases followed less than 36 months	2	
Cases followed less than 42 months	2	
Known dead (all had malignant tumors or other grave disease)		100
Unable to trace (many undoubtedly still living)		32

Several outstanding examples amongst the living patients should be noted. The longest period during which one individual has been observed is now three and one-half years (Fig. 8). This patient has had a serious surgical procedure for relief of a strangulated hernia, and again for intestinal adhesions since this injection of thorium dioxide, and has survived both operations without difficulty. Careful studies 41 months after the injection showed no evidence of impairment of liver function, of anemia or blood changes, or any other findings which could possibly be traced to the procedure of hepatolienography.

Another case is sufficiently interesting to report in detail. The patient, a female, was first seen approximately two and one-half years ago with an extensive carcinoma of the breast. Following the introduction of thorium dioxide sol and the roentgen examination of the liver and spleen with a negative result, resection of the breast was done. Within two months carcinomatous metastases to one lung could be demonstrated. In spite of this she has survived two and one-half years while the lung tumor has slowly increased in size.

Other striking instances may be cited. In one case of carcinoma of the breast (Fig. 7) there were extensive metastases to the spine at the time of the examination. Hepatolienography showed no evidence of metastasis to the liver. With the use of radiation therapy this patient has survived over two years, showing no evidences whatever of deleterious effects from the thorium preparation. Another patient with a carcinomatous ulcer of the stomach, so high that it was not considered resectable, is still living, two years since the hepatolienography was done. The carcinoma has been increasing very slowly in size. A patient with extensive actinomycosis of the lung, on physical examination, appeared to have an enlarged liver. As an extensive surgical procedure was planned in an effort to extirpate the diseased lung, it was thought advisable to examine her liver for possible actinomycotic abscesses. None were found and a partial resection of the lower lobe of the lung was performed by Dr. O. H. Wangensteen. The patient survived several other surgical procedures, eventually succumbing from a brain abscess two and one-half years after the procedure of hepatolienography was undertaken.

In another case, one of unexplained jaundice, thorium dioxide sol was introduced to determine the condition of the liver. Surgical exploration was undertaken later and a permanent drainage tube was inserted into the common duct. Almost three years have elapsed and the patient has suffi-

ciently recovered to have the tube removed. Her condition has greatly improved in the interval and there is not the slightest evidence to indicate any harmful effects from the colloid which she received.

A case of extensive carcinoma of the stomach was subjected to hepatolienography and no metastases were found in the liver. A radical gastric resection was done from which there was an uneventful recovery. This patient was seen over two years later and apparently is still perfectly well.

These cases illustrate the recuperative power of patients who have been subjected to roentgen examination with thorium dioxide sol and indicate the absence of any impairment of their resistance.

In the entire series of 175 cases only two serious reactions occurred. The first, a hemoclastic crisis, has already been reported (7). The second, in which there was a severe chill, was probably due to an intravenous injection of glucose solution which followed the instillation of the thorium suspension. The character of the reaction was typical of that occurring occasionally with glucose injections.

A number of cases have had liver function tests done at various intervals following the introduction of the colloid and no evidence of any impairment has been adduced. There has never been any particular evidence of anemia, blood destruction, or other changes. In no instance have we been able to observe any late deleterious effects upon these patients which could fairly be assigned to the use of this material.

HISTOLOGICAL STUDIES

In this group of cases some 35 individuals have come to autopsy under our supervision. All of these have died of carcinoma or its consequences, three of them being cases of primary carcinoma of the liver. On histologic study the thorium dioxide was found widely distributed throughout the body, very small amounts being demonstrable in the lymph nodes, bone marrow, adrenals, testes, and lungs, in addition to large amounts in the liver and spleen.

It should be noted that the carcinomatous areas in the liver contained no thorium granules with the exception of one case of primary carcinoma of the liver. In this tumor, the thorium was present in large amounts in the abnormal tissue. Whether this was due to the infiltrating character of the malignancy which made it difficult to distinguish the normal from the abnormal cells, or whether the carcinomatous cells retained their normal function of phagocytosis, was not finally determined. The possibility that certain types of primary hepatoma reproduce histiocytic cells, which continue to function normally, must be strongly considered.

In such a group of patients one always expects such terminal changes as cloudy swelling, fatty replacement, and passive congestion in the liver. In this series, cloudy swelling was frequent, passive congestion was present in eight cases, fatty metamorphosis in three, and leukocytic infiltration in one. In this latter case there was a peritonitis which no doubt occasioned this finding. It was impossible to correlate the position of the thorium granules with the points of maximum change except in the cases of chronic passive congestion. In these cases there are definite areas of atrophy which are commonly found with passive congestion. It is notable that there was a very definite concentration of the thorium in the areas of atrophy. This is consistent with the experimental work of Ravenna (26), indicating the viability and normal function of the reticulo-endothelial cells which continue to migrate to points of injury in spite of the presence of thorium within them. No correlation could be observed between the histologic changes and the length of time following the introduction of the thorium dioxide sol, although cases were examined at intervals of from a few days to nine months after the examination.

The histologic appearance of the human liver containing thorium dioxide is illustrated in Figure 1. This is a low power

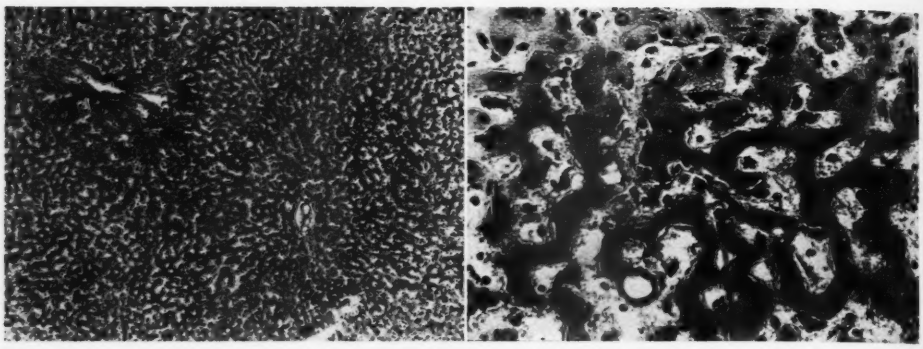


Fig. 1. Fig. 2.

Fig. 1. Low power magnification of microscopic section of liver obtained at autopsy about one month after injection of thorium dioxide sol (thorotrast). The granules of thorium can be clearly made out within the reticulo-endothelial cells. They are widely distributed through the liver. Note that there is no evidence of damage to liver cells or stroma.

Fig. 2. Same case as shown in Figure 1. The high power magnification shows clearly the appearance of the thorium granules in the cells and the absence of any liver damage.

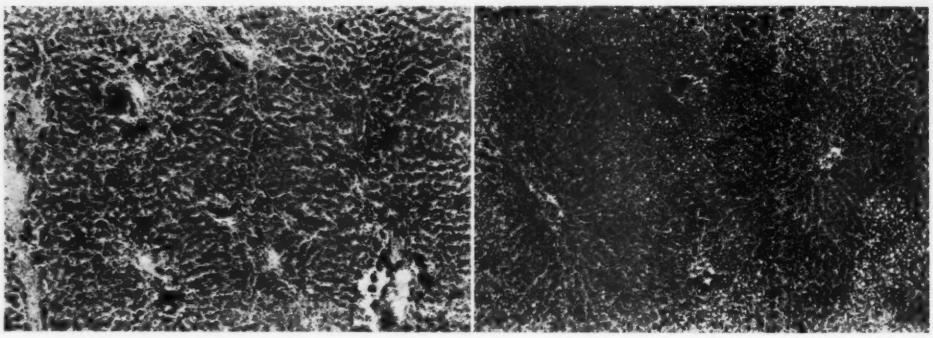
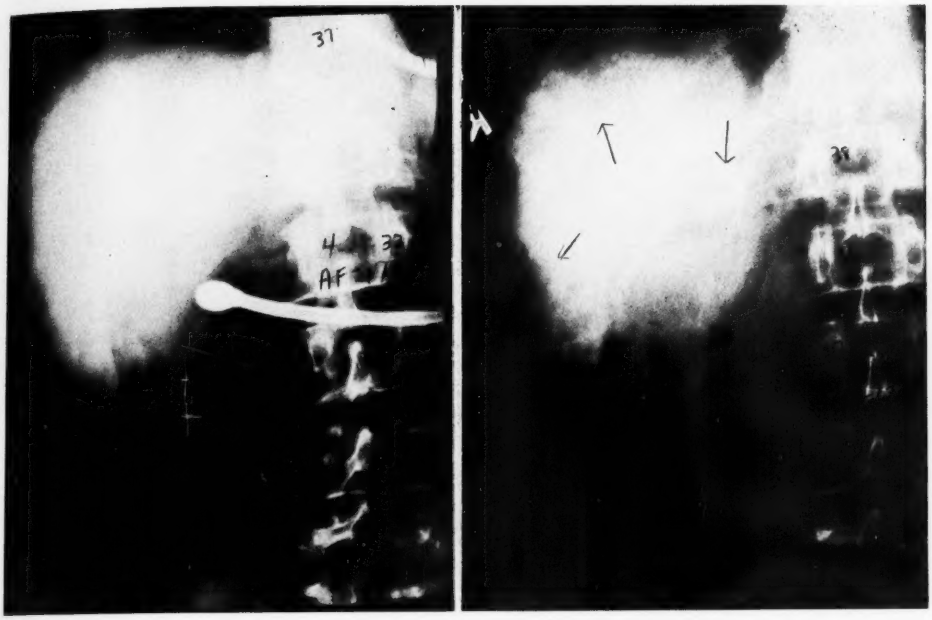


Fig. 3. Fig. 4.

Fig. 3. Low power magnification of microscopic section of liver obtained at autopsy about six months after injection of thorium dioxide sol. This illustrates a type of case in which there is chronic passive congestion with resultant liver atrophy. Note the concentration of thorium granules in the cells around the atrophic areas. The appearance of atrophy is similar to that obtained in the usual case of chronic passive congestion.

Fig. 4. Low power magnification of microscopic section of liver obtained at autopsy about eight months after injection of thorium dioxide sol (thorotrast). Considerable fatty degeneration of the liver is present, the fat globules being well demonstrated. This is typical of findings ordinarily obtained in patients dying of carcinoma. Note that the cells contiguous to the thorium granules show no more involvement than the other cells.

magnification of a microscopic section of the liver, showing the reticulo-endothelial cells filled with the fine granules of thorium. Figure 2 is a high power magnification demonstrating the same findings. The preservation of the normal structure of the cells adjacent to the mass of thorium and the absence of parenchymatous degeneration, atrophy, or fatty replacement should be observed. In Figure 3 is shown the atrophy associated with chronic passive congestion. This is typical of the amount seen in these cases regardless of whether or not thorium was previously given. The concentration of the phagocytic cells containing thorium granules around the atrophied areas is striking and indicates somewhat the retention of their normal reaction to injured tissue. The remaining microscopic section—a low power magnification—is shown in Figure 4. Here, there is approximately the usual degree of fatty de-



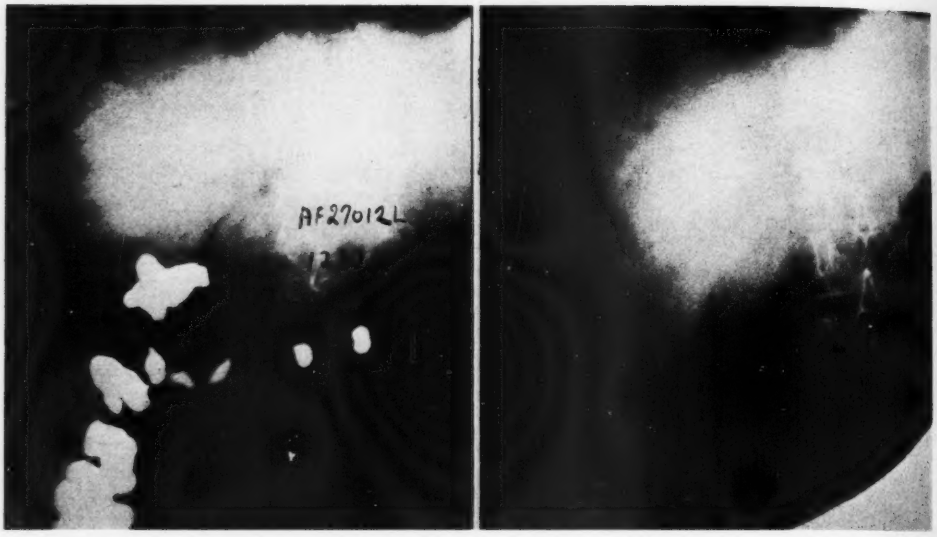
a *b*

Fig. 5. Hepatolienography in a case of carcinoma of the colon. (*a, left.*) Appearance of liver shortly after injection of thorium dioxide sol, showing no evidence of metastasis. (*b, right.*) Same case three months later, showing numerous areas of rarefaction (arrows) in the liver, characteristic of metastases, demonstrated without further injection.

generation frequently seen in patients dying of carcinoma. It is notable that the thorium is not particularly apparent in the areas of the liver which show the most degeneration.

One case which came to autopsy a little over two years after the injection of thorium dioxide sol is of particular interest. This patient had an extensive carcinoma of the stomach, roentgenologically diagnosed. Following hepatolienography, an extensive reaction of the stomach was done by Dr. Wangensteen. Recovery was uneventful and complete. About two years later the patient developed symptoms which led to another surgical exploration, a carcinoma of the colon being found. This was resected but the patient developed post-operative pneumonia complicated by pleural effusion which had a fatal outcome. At autopsy, the sections of the liver showed somewhat less thorium than we have observed in other patients with a shorter duration after injection. The thorium granules were clumped largely near the center of the lobules, and appeared to be present in the periportal spaces adjacent to the bile duct, artery, and vein—no doubt in the lymphatics. There was no evidence of fibrosis, giant-cell formation, or leukocytic infiltration. There was some evidence of slight atrophy of the liver cords. Whether this was due to the manner of death—a rather prolonged post-operative pulmonary infection—or to the thorium we cannot determine. There was no apparent difference in the degree of atrophy of the cells adjacent to the thorium and of those at a distance. This case shows little difference in the appearance of the liver after two years from its appearance at from one to nine months.

It is useful to compare these findings with the reports in the literature of severe or moderate damage to the liver and spleen after the injection of thorium dioxide sol. These changes in the liver consist largely of fatty degeneration, atrophy, and fibrosis,



a *b*

Fig. 6. Hepatolienography with follow-up examination. (*a, left.*) First examination, showing a rather small liver with slight mottling, but fairly homogeneous shadow, characteristic of normal appearance with thorium dioxide sol. (*b, right.*) Same case 11 months later, showing characteristic mottling of shadow which is frequently found after approximately one year.

while in the spleen and lymph nodes there is largely shrinkage of the lymphoid tissue with atrophy and fibrosis, often accompanied by perivascular fibrous tissue proliferation. The exact mechanism by which these changes are produced has not been definitely determined. It seems improbable that it is due to a radiation effect, as the histologic appearance is not at all that of radiation necrosis. A toxic effect is a possibility; this would necessarily have to be specific for the tissues of the liver, spleen, and for lymphoid tissue, as the injection of thorium dioxide subcutaneously produces practically no deleterious effects in the local area. Such a specific toxic effect seems improbable. There is, finally, the possibility that these changes are due to a foreign body reaction. The description of the lymph node changes particularly (9) suggests this type of process. In those experiments in which very large doses were used, the changes appear to be definitely of this character. Reports of leukocytic infiltration approaching abscess formation are probably due to some coincidental infection.

Critical study of our microscopic sections reveals few, if any, of these changes. There are no foreign body giant cells; little, if any, fibrosis, and no perivascular tissue reactions. While it is possible that some of the atrophy demonstrated, *e.g.*, in Figure 3, might be due to the thorium preparation, the amount and character of it do not suggest this at all, the congestion being quite sufficient to account for it in its entirety. Likewise, the fatty degeneration might have been caused, at least in part, by the foreign substance; here again the tissue differed in no respect from that frequently found in this type of patient to whom thorium dioxide had not been given. The histologic changes demonstrated bore no apparent relation, as to location, to the thorium granules which were present. The cells closest to the foreign substance showed no greater degree of damage than those at a greater distance.

The impression gained from these histologic studies is that there is little or no damaging effect upon the liver, so far as can be determined by microscopic examination in a nine-month period of observation.

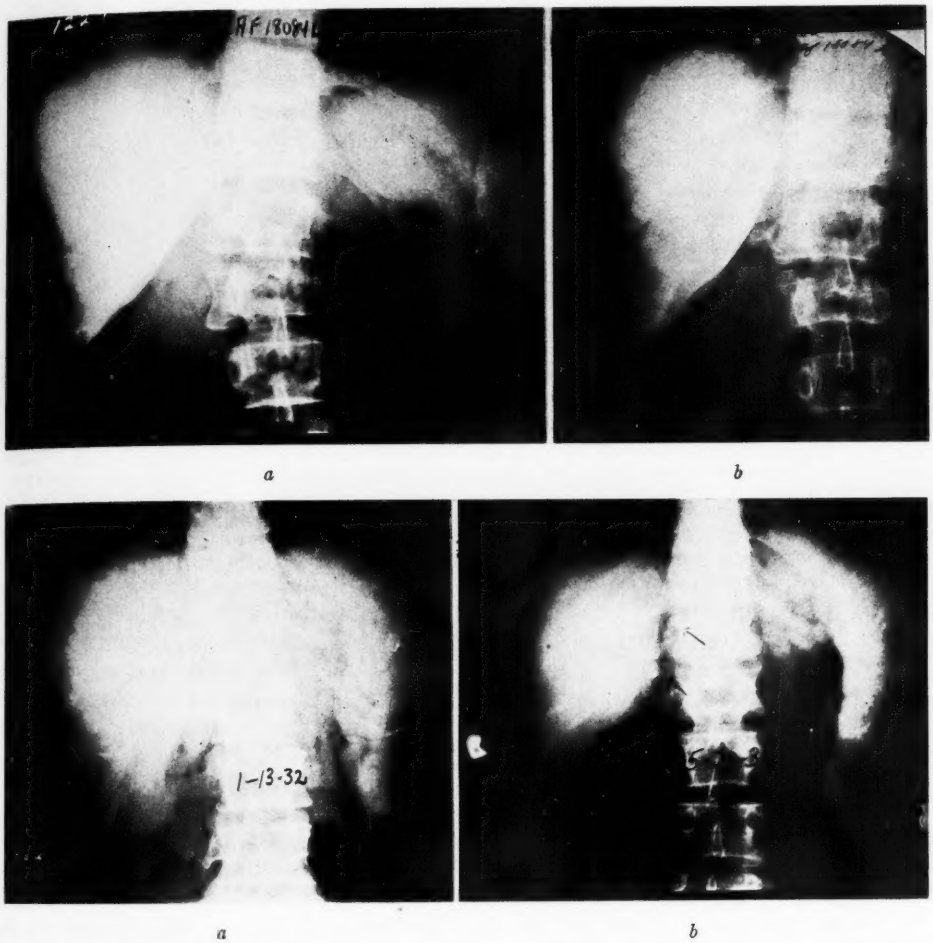


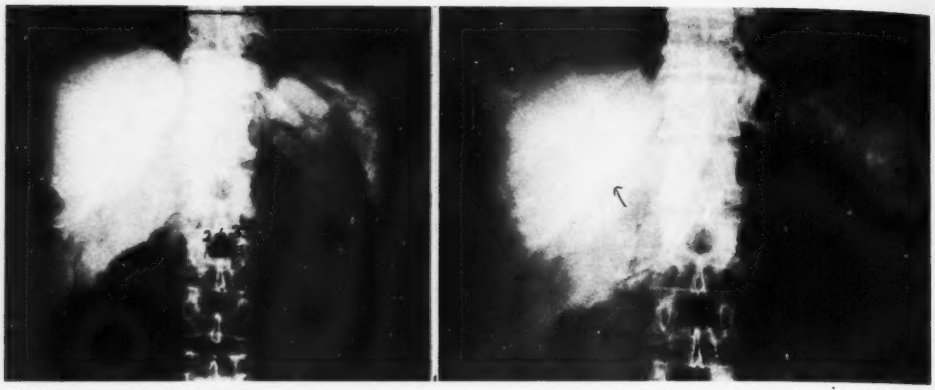
Fig. 7. Hepatolienography in a case of carcinoma of the breast with metastases to the second lumbar vertebra. (*a, upper left.*) Note the homogeneous shadow of the liver clearly delineated, and the characteristic, slightly mottled shadow of the spleen. (*b, upper right.*) Same case re-examined one and one-half years later shows the typical mottling of the liver shadow and dense nodular shadows along the left border of the liver (arrow), typical of excretion of thorium into hepatic lymph nodes.

Fig. 8. Hepatolienography in a patient with enlarged spleen of undetermined origin. (*a, lower left.*) Film made shortly after injection of thorium dioxide sol, showing normal liver and enlarged spleen. Note the absence of shadows along the left border of the liver. (*b, lower right.*) Same case three and one-half years later. A slight mottling of the liver shadow is now apparent. The spleen shows about the same size and also an increase in the mottled appearance. Characteristic shadows along the left border of the liver representing hepatic lymph nodes filled with thorium are shown (arrow).

Certainly none of the alarming changes observed in animals were found here, and it is very questionable whether any of the abnormalities which we observed could fairly be assigned to the thorium dioxide sol.

ELIMINATION OF THORIUM

Finally, there arises the question of the eventual fate of the thorium after it has been injected. We have been enabled to re-examine 32 patients of this series. Roentgenograms of the liver and spleen in 10 cases were made from three months to one year after the original study. In 22 cases the re-examination was done from one to three and one-half years after the introduction of the thorium dioxide sol. In most instances there has been little reduction in



a *b*

Fig. 9. Hepatolienography in a case of carcinoma of the stomach without metastasis. (*a, left.*) Note the shadow of the liver, apparently normal, as well as a brilliant delineation of the spleen. (*b, right.*) Same case, re-examined about a year and one-half later, shows a peculiar streaked concentration of thorium along the lower margin of the liver, and definite hepatic lymph nodes near the spine (arrows). Note the mottled appearance of the spleen and some nodules along its hilus suggesting splenic lymph nodes also filled with thorium.

the intensity of the shadow of the liver and spleen. There is a change but it is relatively minor, indicating that only a small amount of the colloid has left these organs in this interval.

As has been previously reported, some advantage can be had from this slow elimination in that repeated roentgen studies of the liver may be made without additional injection. In that way carcinomatous metastases to the liver may appear in later films although they were not present when the first examination was made. Such a case is illustrated in Figure 5. This patient had a carcinoma of the colon, and on the original hepatolienography (Fig. 5-*a*) there was seen no evidence of metastases. Resection of the colon was done, and manual exploration of the liver also revealed no evidence of metastases. When the patient returned some three months later for closure of the colostomy, re-examination revealed the typical extensive carcinomatous metastases shown in Figure 5-*b*.

Two characteristic changes are present in the majority of the cases when they are examined a year or more after the injection. There is shown a redistribution of the opaque substance in the liver; the latter shows a marked degree of fine mottling in contrast to the rather homogeneous character of the shadow on the original examination. An illustrative case is shown in Figure 6. The roentgenogram made 48 hours after the last injection is shown in Figure 6-*a*, the liver giving the usual homogeneous dense appearance with the vascular tree, and the gall-bladder fossa appearing as areas of decreased density. In Figure 6-*b* the roentgenogram made eleven months later is presented. In this can be seen the finely mottled character of the liver shadow. From the work of Kadrnka (16) and of Naegeli and Lauche (20) on animals, it would appear that this is due to an extension of the thorium dioxide into the lymphatics around the central vein. It may also be due in part to a migration of the reticulo-endothelial cells of the liver to this region. The tendency toward elimination of the injected substance through the lymphatics is thus apparent.

Further evidence of this manner of elimination is afforded in Figure 7. The roentgenogram of the liver made shortly after the injection of thorotrast is presented in Figure 7-*a*. A carcinomatous metastasis to the second lumbar vertebra is clearly apparent. The striking representation of the spleen should also be observed. The examination of the liver one and one-half years later is shown in Figure 7-*b*, and here

may be observed a group of shadows, along the left border of the liver, which are not present on the original examination (Fig. 7-*a*). These are undoubtedly the hepatic lymph nodes into which the thorium dioxide has extended. The characteristic mottling of the liver shadow may be noted here also. Further drainage into the mediastinal and diaphragmatic lymph glands should be expected, although we have been unable to demonstrate it in any of our cases. The same phenomenon is illustrated even more strikingly in Figure 8. The original roentgenogram (Fig. 8-*a*) shows a considerable enlargement of the spleen and a normal liver. The absence of any abnormal shadows along the left border of the liver may be noted. In Figure 8-*b* is shown the roentgenogram obtained about three and one-half years later, and the characteristic appearance of the hepatic lymph nodes filled with the opaque substance is clearly shown. The absence of any particular change in the size of the spleen is strong evidence against the occurrence of atrophy of the lymphoid structures which has been described in animals. It should be noted in this case that a period of three and one-half years has failed to diminish the intensity of the liver and spleen shadows.

The case illustrated in Figure 9 is somewhat different from the usual finding. The first roentgenogram (Fig. 9-*a*) demonstrates a fairly large liver, otherwise normal, and an unusually well-defined spleen. On reexamination about 19 months later (Fig. 9-*b*), the hepatic lymph nodes are well shown, but there is in addition an unusual concentration of the thorium dioxide in a linear fashion under the costal margin. This is probably due to the presence of some unusually large lymphatics in this area.

These findings correspond exactly with those of Naegeli and Lauche (20), who report a study on one dog over a period of three years. Repeated biopsies of the liver have shown relatively little damage although two to three times the usual dose was given. The dog has survived numerous laparotomies and other surgical procedures. An abdominal exploration at the end of the third year revealed the hepatic lymph nodes filled with thorium granules. These authors sound another warning as a result of this observation. They believe that there may be a greater concentration of the thorium in the lymph nodes than in the liver, hence a more marked necrotic and atrophic effect might be possible. In actuality, the biopsies in this one dog indicate areas of necrosis in the lymph nodes but they are well encapsulated. There is, however, a definite atrophy and diminution in amount of the lymphoid tissue.

The reports of Leipert (17) and other investigators (29), that large quantities of thorium dioxide sol may be eliminated from the body within a year, seem to be contradicted by our comparative studies in clinical cases. Whatever elimination takes place from the liver seems to extend into the lymphatics and lymph nodes but the thorium is still present in the body. An examination of the roentgenograms shown in Figure 8, taken almost three and one-half years apart, indicates clearly how slowly this removal of the thorium takes place. This fact, no doubt, presents the most serious objection to the use of this substance for roentgen diagnosis.

SUMMARY

We may summarize our experience with the use of thorium dioxide sol (thorotrast) for roentgen diagnosis of the liver and spleen in 175 patients as follows:

(1) The procedure permits of highly accurate diagnosis, particularly of metastatic or primary carcinoma of the liver.

(2) With rare exceptions, the immediate reactions to the injection are of no importance.

(3) No apparent change in the resistance of the patients injected with this substance could be determined.

(4) There were no deleterious effects, observed over a period of years, that could in any way be assigned to the thorium.

(5) Autopsy studies in 35 cases revealed little or no damage to the liver which could

fairly be ascribed to the procedure of hepatolienography.

(6) Repeated roentgen examinations on 22 cases from one to three and one-half years after the injection indicated little or no elimination of the injected material from the body.

(7) Redistribution of the thorium into the lymphatics of the liver and extension into the hepatic lymph nodes was observed in almost all the cases that were re-examined after a year or more had elapsed.

CONCLUSIONS

Little or no harm can be demonstrated, as yet, from the use of thorium dioxide sol when used in small doses in the roentgen examination of the liver and spleen in humans.

Nevertheless, caution should be exercised in its use because of the following reasons: (1) the eventual radio-activity of the material has not yet been determined; (2) it is eliminated very slowly, if at all, so that a foreign body will remain in the liver and spleen; (3) the extension into the lymph nodes in greater concentration may produce atrophy of the lymphoid tissue, the eventual results of which cannot yet be predicted.

It would be well, for several years to come, to confine its use, when injected intravenously in large enough doses for proper demonstration of the liver and spleen, to older individuals suffering from very grave diseases.

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RIB DEFECTS SIMULATING PULMONARY CAVITATION

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DEVELOPMENTAL and pathologic changes in the ribs as seen in radiographs may simulate cavitation in the underlying lung. The cavities most frequently seen in radiographs of the chest are produced by tuberculous cavitation, the cavitation of an abscess, and air-containing pockets due to broncho-pleural fistulæ.

Accurate information as to the presence of cavitation in the lungs is usually of great clinical importance. The shadow of a cavity may be the deciding factor in making a positive diagnosis of tuberculosis in an area of infiltration of doubtful nature. Collapse therapy in tuberculosis is based primarily upon the presence of cavitation. Simple infiltration or consolidation, which has been produced in the lung by a non-tuberculous type of infection, does not call for surgical interference, but if an abscess cavity is found in such an area, operation may be indicated.

At the Cleveland City Hospital there have been observed 14 cases in which the radiographs showed changes in the ribs which could readily simulate cavitation if there were a pathologic process present in the underlying lung. Sweaney (1) has made similar observations. The confusing shadows in the cases to be presented are produced by anomalous rib development or by a portion of a rib which has enlarged to enclose an area of bone absorption. This expanded portion of bone casts an annular shadow of increased density, which may be mistaken for the zone of infiltration or fibrosis which often surrounds a cavity in the lung. The central area of lesser density casts a shadow similar to that produced by air in a pulmonary cavity. White (2) has mentioned bifurcation of the ribs, and Fleischner (3) has noted fenestration.

In some of the cases to be presented, close inspection will show the true nature of the annular shadows because there are no pathologic changes in the underlying lungs, but the presence of infiltration or fibrosis in these areas could very easily mask the outlines of the expanded ring of bone in the rib and give rise to a false diagnosis of pulmonary cavitation. In cases of doubt, more heavily exposed films from varying angles, or stereoscopic films should aid in determining whether the shadow is produced by a cavity in the lung or by unusual configuration of the rib overlying that area.

CASE REPORTS

Case 1. A white male, aged 19 years, was admitted four months after pulmonary tuberculosis had been diagnosed elsewhere. A radiograph of the chest showed densely mottled and streaked shadows in the upper half of the right lung-field and in the lower right hilar area. There was an area of rarefaction 2 cm. in diameter just beneath the right clavicle, which was diagnosed as a cavity in an area of tuberculous infiltration in the lung. Pneumothorax was instituted because of the cavitation. Two months later there was an hemoptysis of two ounces. A few days after the hemoptysis, suspicion arose that the cavity might have been in a rib. Further radiographs from different angles and of greater density, using Bucky diaphragm technic, proved that the cavity was in the first right rib and not in the lung. Sinuses developed in the chest wall. Incision revealed necrotic bone in the rib and tubercle bacilli were found in the material obtained from it. Communication with the hospital in which the patient was previously diagnosed as being tuberculous revealed the cavity in the rib to have been diagnosed there, also, as a pulmonary cavity.

Case 2. A colored male, aged 22 years, was diagnosed, in 1926, as having pulmo-

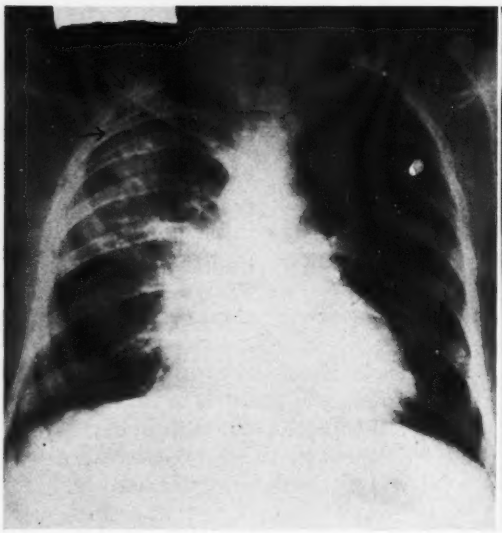

Fig. 1. Case 1. Regular exposure, diagnosed as pulmonary cavitation.

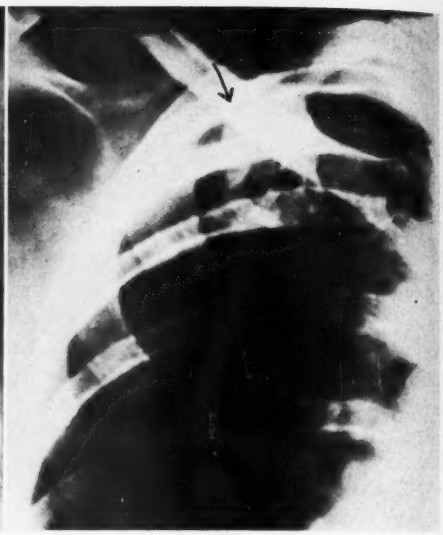

Fig. 2. Case 1. Heavy exposure, showing cavity to be in the rib and not in the lung.

nary tuberculosis. Tuberculous infection of the ilium was found at that time. In 1929, tubercle bacilli were found in pus draining from the right malar bone. A soft tissue swelling over the second and third right ribs, anteriorly, resolved without suppuration after ultra-violet light therapy. A recent film of the chest showed the upper mediastinal shadow to be enlarged to the right. Between the third and fifth right ribs, anteriorly, was seen an area of cloudy increased density. Near the center of this area was seen a denser ring 3 cm. in diameter enclosing a space of lesser density having the appearance of a cavity. Closer inspection reveals the anterior end of the fourth right rib to be expanded and to enclose a cavity 2 cm. in diameter in the rib. The lung beneath this deceptive shadow contained infiltration but no cavity.

Case 3. A white male, aged 22 years, was known to have had pulmonary tuberculosis. A film of the chest showed mottled and streaked shadows throughout the upper two-thirds of the left lung due to tuberculous infiltration and fibrosis. There was increased density about the right hilus, and in this dense region was a rarefied shadow, probably due to a pulmonary cavity. In the second left interspace was an annular shadow 3 cm. in diameter, which undoubtedly was due to a pulmonary cavity. In the region of the second costal cartilage (which ordinarily casts a very faint or no shadow) was a circular shadow of lessened density 2 cm. in diameter surrounded by a ring of increased density. The first impression, since the patient was known to have had pulmonary tuberculosis with cavitation, was that this annular shadow represented another cavity in the lung, but closer inspection showed the sixth right rib to have a double origin and to be attached to two vertebræ. The space between the two heads of origin produced the appearance of a cavity.

Case 4. A white girl, aged 11 years, was subjected to resection of the ninth left rib, in June, 1934, to drain an empyema following scarlet fever. In November, 1934, drainage still persisted, and a bronchopleural fistula was demonstrated. A radiograph of the chest showed haziness in the lower third of the left lung-field, and through this haziness was seen an annular dense shadow 3 cm. in diameter enclosing a rarefied area. Closer inspection revealed this shadow to be due to bone regeneration

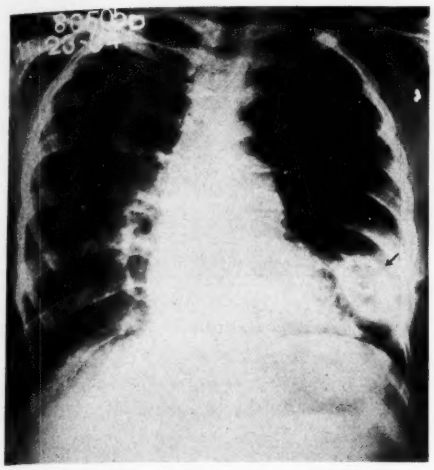

Fig. 3. Case 4. Deformity of rib following resection.

from the bed of the resected portion of the eighth rib. Bone regeneration of this type is fairly common.

Case 5. A white male, aged 70 years, complained of cough, shortness of breath, and loss of weight. A film of the chest showed haziness at each apex, with fibrotic shadows scattered about each apex and along the entire mediastinal border of the right lung. The first left rib was wider than is usually seen and contained a well defined area of bone absorption. Through the shadow of the first right rib was seen an irregularly outlined area of lessened density which probably would have been diagnosed without question as a pulmonary cavity, because of the presence of infiltration and fibrosis in that area, had not the rib on the opposite side shown such a well-defined cavity. A heavily exposed film from a different angle was required to obtain the correct diagnosis of a cavity in the first right rib.

Case 6. A colored male, aged 30 years, complained of cough and expectoration for four months, and of a tender spot in the upper right thorax, anteriorly. A radiograph showed irregular shadows of increased density in the upper third of the right lung-field. The markings in the area draining the left apex were of increased thickness.

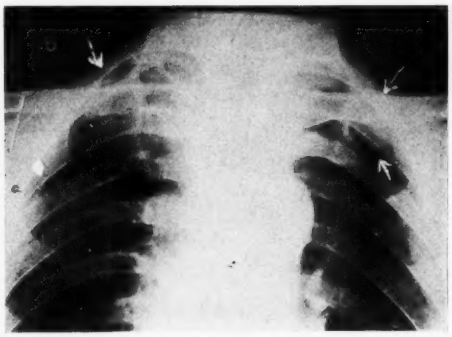

Fig. 4. Case 5. Cystic changes in right and left first ribs.

There were shadows of cavities in the upper fourth of the left lung-field. The second right rib was irregular. Pus that contained tubercle bacilli was aspirated from the tender spot in the right side of the thorax. Heavily exposed films demonstrated cavities in the first and third left ribs but not in the lung.

Case 7. A white male was referred without history for a radiograph of the chest. The markings about each hilus were of increased thickness. The interlobar septum on the right side was thickened. The anterior portion of the third left rib was wider than is usually seen and formed a circular shadow 3 cm. in diameter. The left lung was quite clear and the nature of the shadow was evident, but if a pathologic change in the lung had been present, confusion in diagnosis might have arisen.

Case 8. A colored female, aged 46 years, was referred for a film of the chest because of symptoms suggestive of tuberculosis. There were a few shadows of calcification in the second right interspace. The markings in each subapical region were rather heavy. Through the shadow of the anterior portion of the first left rib was seen a rarefied area 1.5 cm. in diameter, which was shown on closer inspection to be due to a cyst-like area of absorption in the rib. If there had been pathologic changes in the apex of the lung that would blur the outlines of the rib, this area of bone absorption might have been mistaken for a cavity in the lung.

Case 9. A white male, aged 55 years,

Fig. 5. Case 13. Osteomyelitis of ribs, following compound fractures.

was admitted because of diabetic gangrene in the foot. A film of the chest was requested because of a cough. The markings were somewhat increased in number and density throughout both lungs. Through the shadow of the first right rib was seen a round area of diminished density 1 cm. in diameter. The outline of this rib was of the same size and shape as the corresponding rib on the opposite side. A more heavily exposed film demonstrated the cavity to be in the rib and not in the lung.

Case 10. A white male, aged 25 years, was referred for radiographic examination of the chest because of a cough and family history of tuberculosis. Many fibrous strands were seen in the area draining the right apex. A spur of bone extended medially and upward from the midportion of the second right rib to make contact with a spur extending laterally from the first rib. The underlying lung was clear enough so that the nature of the curving shadow was apparent, but if dense infiltration had been present it is not unlikely that a mistaken diagnosis of cavitation in the apex, above

Fig. 6. Case 14. Autopsy specimen. Cavity in expanded rib.

the spur, would have been made, as the curved spurs could simulate the dense wall of a cavity.

Case 11. A white male, aged 45 years, complained of fever, shortness of breath, and pain in the right side of the chest. The film exhibited marked density in the lower third of the right lung-field, gradually fading out toward the apex. Through the haziness in the middle third was seen an oval area of rarefaction 2 × 4 cm. in size, surrounded by a dense ring. This had the appearance of cavitation in the lung with pleural effusion. A large amount of fluid was removed from the pleural cavity. The removal of the fluid permitted much better visualization of the chest, and in another film the shadow, which had appeared to be that of a large cavity in an infiltrated lung, was seen to be due to a deformed rib. Other ribs were then seen to be deformed, and it was found that the patient had suffered from an accident a year or two previously, the accident being followed by drainage of pus from a wound in the thorax. The cystic area in the rib, with the surrounding expanded ring of bone, was probably due to osteomyelitis subsequent to a compound fracture.

Case 12. A white male, aged 40 years, under routine examination showed an apparent cavity at the apex of the right lung. The first right rib was markedly enlarged anteriorly, measuring 4 cm. in width. A cyst-like cavity was seen in the expanded portion of the rib, the thin borders of the rib producing the illusion of a cavity in the lung.

Case 13. A white male, aged 41 years, was examined because of signs indicative of tuberculosis. In the fifth left interspace was seen a definite area of infiltration. The cardiac outlines were blurred by pericardial thickening. There was a synostosis between the first and second right ribs, the bridge of bone connecting these ribs being curved so that the question of cavitation in the lung would probably have arisen had infiltration been present in the upper fourth of the right lung.

Case 14. A colored male, aged 42 years, with signs and symptoms very suggestive of pulmonary tuberculosis, showed in the chest film many small nodular and streaked shadows in the upper third of the right lung-field and at the left apex. There were shadows suggesting small cavities at each apex. In the lower right hilar area there was a shadow that strongly suggested a cavity. There was a slight deformity of the fifth right rib, the cavity lying within the shadow of the rib. There was uncertainty as to whether the cavity was in the rib or in the lung. At autopsy, the cavity was found to be in the anterior portion of the fifth rib. Microsopic examination revealed no active inflammatory process in the rib, but it was thought that the cavity was due to tuberculous osteomyelitis.

SUMMARY

Fourteen cases exhibiting possible sources of error in the radiologic diagnosis of pulmonary cavitation have been presented. Four of them had congenital malformation of the ribs. One had deformity of a rib following its resection. In nine cases, annular dense shadows with rarefied centers were produced by bone surrounding a cavity due to infection or a cystic change in a rib, the width of the ring of bone being much greater than the normal size of the rib.

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RETARDATION OF BONE GROWTH FOLLOWING ROENTGEN IRRADIATION OF AN EXTENSIVE NEVO-CARCINOMA OF THE SKIN IN AN INFANT FOUR MONTHS OF AGE[1]

By ROLLIN H. STEVENS, M.D., *Detroit*

I REPORT the following case, from Grace Hospital, Detroit, because of its interest, particularly from four standpoints:

(1) The case is one of an extensive vascular nevo-carcinoma of the skin of the left thigh, vulva, and left lower quadrant of the abdomen in a child four months of age.

(2) It was treated with 200 kv. roentgen therapy, after which the growth completely disappeared and the child has remained free from evidence of carcinoma for five years.

(3) There followed a marked retardation in the growth of the pelvis, femur, tibia, and fibula on the affected side, although the radiation was confined to the upper two-thirds of the femur, the left lower quadrant, and the vulva.

(4) Four years and nine months later, staphylococcic osteomyelitis of the left femur developed.

There has been a good deal said about the arrest of soft tissue growth, but we have not found much in the American literature, at least, on the subject of retardation of bone-growth by irradiation. Recently, Haenisch[2] reported a case of a young girl, about three years of age, whose breast was irradiated post-operatively for some kind of growth in the upper arm. Many years later, there was noted a marked retardation of all the tissues in the field-mamma, skin and its appendages, half the thoracic wall, scapula, clavicle, and humerus. Haenisch gives a brief review of the literature of the subject—all European—concerning biologic experimentation and clinical observation.

[1] Presented before the Radiological Society of North America at the Twentieth Annual Meeting, at Memphis, Tenn., Dec. 3–7, 1934.

[2] G. F. Haenisch: Fortschr. a. d. Geb. d. Röntgenstrahlen, July, 1934, **50**, 78–86.

HISTORY

J. Di C., female, Italian, born July 12, 1929, was first seen by Dr. A. Font, and brought by him to Grace Hospital on Oct. 31, 1929. Her weight was 11 pounds, 5 ounces; her temperature was 104° (R). There were scattered râles throughout the chest. There was a vascular swelling, 10 cm. in diameter, involving the whole of the left thigh, vulva, and lower abdomen, and the parents said it was growing rapidly. They stated that the growth was present as a purplish lesion at birth, and involved a small area in the middle of the anterior portion of the left thigh. The left thigh was swollen to more than three times its normal size, and the swelling extended into the vulva and across the abdomen. The involvement of the latter two areas was very recent. The color was a dark purplish-brown, being more purple over the abdomen.

Dr. Font made a biopsy, and a severe hemorrhage, very difficult to control, followed. The pathologic report by Dr. Clarence Owen, pathologist of Grace Hospital, was as follows: "Epidermis negative. In the cutis are several areas of nevus cells, exhibiting marked anaplastic tendencies, with formation of spindle cells. No alveolar or acinous formations present. The diagnosis was nevo-carcinoma."

At the earnest request of the parents, x-ray therapy was begun on Nov. 5, 1929, although we had no hope of accomplishing anything beneficial, and we pointed out to the parents that the ovaries would be destroyed and unknown disturbances of metabolism might result.

Treatment was given as follows: 200 kv., 1 mm. Cu and 1 mm. Al filter, 30 ma., 50 cm. distance, 122 r at a dose, November 5, 9, 11, 12, 13, 14, 15, and 16, respectively—a

total of 976 r in 11 days. At the end of this time the tumor was growing, and became more and more painful, so the treatment was discontinued. After two or three weeks, however, the child improved; the tumor grew smaller and the pain subsided. This improvement continued for two or three weeks and came to a standstill. We were encouraged and urged to resume treatment. Accordingly, on Jan. 2, 1930, we started treatment again on a "saturation" technic. An area 20 × 10 cm. on the thigh anteriorly and posteriorly, and extending over the lower abdomen, was treated daily, with 1 mm. of copper and 1 mm. of aluminum at 50 cm. distance, 200 kv. and 30 ma., until Jan. 20, 1930, giving an estimated total effective depth dose in the bone of about 840 r in 18 days. The tumor rapidly diminished so that within three or four weeks after the end of the treatment the left thigh was about the same size as the right, and the swelling had left the vulva and abdomen. The skin became red, then brown, and desquamated moderately.

Progress Notes.—The following is a synopsis of progress notes and laboratory findings in Grace Hospital: On Oct. 15, 1929, and for the next seven days after admission, the temperature range was from 100.4° (R) to 104° (R). During the month of November, the temperature was slightly above normal, ranging from 99.8 (R) to 101.6 (R); 101.6 (R) was the temperature recorded the day after completion of the first series of deep x-ray therapy. The thigh showed no improvement; the carcinoma continuing to grow, getting much darker, more painful, and swollen. The temperature varied only slightly above normal for the remainder of November. On Oct. 6, 1929, her weight was 12 pounds and 6 ounces. The temperature was normal for December. Further x-ray treatment was given during January with considerable improvement. The patient at times was quite nauseated after treatment; there was no rise in temperature. On Feb. 6, 1930, the temperature started to rise and was 100.6 (R). The following two days the temperature varied between 104.2 (R) to 101.8 (R). No apparent explanation for the rise in temperature was found; it came down gradually, being normal on Feb. 13, 1930.

Roentgen and Laboratory Reports.—Roentgenograms taken on Oct. 16 and 31, and on Nov. 19 and 26, 1929, revealed no bone pathology of the left femur, rather dense hilar shadows in the chest, and considerable increase in density and width of pulmonary markings throughout the central and middle areas of both lung-fields. The possibility of lymphatic intrathoracic neoplastic metastases must be considered, although one must also consider a possible bronchopneumonic foci or a chronic bronchitis. On Feb. 6, 1930, a re-examination of the chest and long bones, after a course of x-ray therapy, revealed no convincing evidence of neoplastic invasion. On Oct. 16, 1929, a white blood count showed 17,500 leukocytes, 43 per cent neutrophils, and 57 per cent small lymphocytes. Blood Wassermann was negative. On Feb. 6, 1930, the blood count was: hemoglobin, 56 per cent; red blood cells, 3,350,000; white blood cells, 6,400; neutrophils, 65 per cent; large lymphocytes, 10 per cent; small lymphocytes, 25 per cent. The patient was discharged from Grace Hospital on March 6, 1930.

We did not see the child again until Oct. 4, 1933, when she was brought to the hospital by Dr. Font. She was then four years old. She appeared to be perfectly well except for a shortening of about two inches of the left limb. The parents informed us that she had started to walk at the age of 18 months, and the shortening was first noticed in the Spring of 1932, about fifteen months after the deep therapy. Her parents stated that the lameness was continually growing worse. There was some slight atrophy of the skin and other soft tissues of the limb. The roentgen examination was reported as follows: "Re-examination of the chest reveals no convincing evidence of neoplastic metastases anywhere in the chest. There are pulmonary changes, however, which we believe could be best interpreted as evidence of a chronic, rather pronounced bronchosinusitis, although tuber-

Fig. 1. Oct. 20, 1929: taken before first series of treatments.

Fig. 2. Oct. 20,1933: taken four years after treatment. There is shortening of the right tibia and fibula.

cular etiology—childhood type tuberculosis—may have to be ruled out by further investigations. The development of the thoracic cage is entirely symmetrical. A comparative examination of the pelvis and the lower extremities, exclusive, however, of the feet, shows a marked retardation of the growth of the entire left lower extremity, including the pelvis, so that the left leg is considerably shorter than the right. Taking into consideration the differences in opacity of the two extremities produced by the differences in their size, we feel, nevertheless, that the *left-sided osseous structures are somewhat porotic and more loosely structured*, besides being smaller in all diameters. The most striking change observed, however, is a certain *broadening of the left femoral neck*, combined with *quite irregular outline of the epiphyseal border* and *markedly irregular structure of the distal left femoral epiphysis*."

She was next seen by us on June 2, 1934, when the shortening of her leg seemed to be increasing. Roentgen examination, however, revealed a condition differing but little from that of Oct. 4, 1933. The left limb felt hot and she had a slight temperature. The case was then lost from our care. Just recently we have learned she had been sent to the Children's Hospital, in June, 1934, by a Board of Health nurse who had been visiting one of the other children at their home, and had been at the hospital ever since.

Dr. Grover Penberthy, Surgeon at the Children's Hospital, into whose care the case was given on June 19, 1934, has kindly furnished me the following condensed report on the case since that time:

J. Di C., white, aged 5 years, was admitted on June 19, 1934. *History:* Swelling of left thigh for five weeks, with four days of fever. *Examination:* Swollen, tender,

Fig. 3. June 19, 1934, showing staphylococcic osteomyelitis.

Fig. 4. Nov. 21, 1934, showing osteomyelitis healed. There is shortening of the right femur.

indurated entire left thigh, with increased heat and fluctuation, and two inches shortening of the femur. *Laboratory Findings:* White blood cells, 34,000; polymorphonuclears, 89 per cent; urine negative; Kahn test negative. *X-ray:* Definite but early osteomyelitis of the left femur in its middle third. *Course:* temperature 101 degrees; pulse, 100; patient was operated upon the day of admission; lateral and mesial incisions; 8 ounces of pus obtained; saucerization done; through-and-through drains; *Cast:* Culture report, *Staphylococcus albus;* developed large area of induration over the lower abdomen on left side, left groin, and upper thigh. Blood transfusions were given on June 28 and 29. Old incisions opened more widely on July 7, 1934. Induration gradually decreased. The patient was sent to the Crippled Children's Hospital at Farmington on July 31, 1934; readmitted to Children's Hospital on Oct. 23, 1934, because of the development of a flexion contracture of the left hip. Hip manipulated under gas on Nov. 10, 1934, after a period of skin traction and bent frame failed to correct it. The patient remained in the hospital and check-up x-rays were taken. All wounds of the left thigh were healed.

Roentgenograms were made on Nov. 21, 1934. They showed the field of saucerization healed over nicely. In the lower end of the femur, however, there was marked demineralization, and the diaphyses of the upper ends of the left tibia and fibula exhibited changes suggestive of green-stick fracture.

COMMENTS

The problem here of treating, by radiation, a carcinoma in an infant five months of age is very different from the problem of treating an adult. All the tissues, normal

and pathologic, of the child of this age are much more embryonal in character, and consequently much more sensitive to x-radiation.

The most important tissues in the line of direct radiation were those of the skin, sexual organs, the intestinal tract, and the bones. The epidermis, as is generally known, is sensitive to radiation, but has wonderful powers of recovery, providing its nutritive functions resident in the subjacent cutis, which is not so sensitive to radiation, are not damaged to too great an extent, especially by any caustic action of the rays.

There appears to have been no serious damage done to the intestine, although the colon on the left side and the rectum received a considerable dose of radiation. The ovarian function, of course, should have been destroyed beyond possible repair, although it will be some years before we can know for a certainty just what has happened there.

Several papers, and a recent book by H. A. Harris, concerning the histologic anatomy of developing bone, the experimental and clinical study of diseases of bone, especially rickets, scurvy, tuberculosis, syphilis, etc., are full of interest when studied in connection with this case.

By a clever piece of work, Harris claims to have demonstrated mitoses in cartilage cells, and to have localized the zones of active mitoses in the cartilage skeleton of the embryo. He found an "annulus" of mitotic cells in the ends of long bones, which, multiplying, grow out in three directions, to form the articular cartilage, the cartilage of the epiphysis, and the cartilage of the epiphysial line. The pattern of growth of these cells, which later becomes calcified, is the later pattern of the bone. These dividing cells give rise to "diaphysial bone with its high osteogenetic power in repair, epiphysial bone with a low-grade power of osteogenesis in repair, and hyalin cartilage with minimal powers of repair."

The nutrition of these three parts concerned in growth in the cartilaginous stages is similar to that of the skin. The development of generation after generation of cartilage cells from the "annulus" of mitotic cells to gradually aging cartilage cells, which finally die and are cast off, the matrix becoming calcified, is a process comparable to the development of the stratum squamosum from the stratum germinativum of the epidermis. The sensitivity of the multiplying cells of the epidermis, during mitosis to radiation, is well known. It is fair to assume there may be a similar radiosensitivity on the part of the cartilage cells in a similar stage of reproduction. Is it possible that varying degrees of monstrous cartilage cells may appear as a result of their being irradiated, which would produce a poorly differentiated type of bone?

But what caused similar changes in the tibia and fibula which were not radiated?

It would seem that a direct or indirect disturbance of the chemistry of the circulating nutritive fluids of the side irradiated might be responsible. There has not been a great deal of work done on the chemistry of cells as yet, but considerable has been learned from tissue culture *in vitro*.

This Society is familiar with the pioneer work of Burrows in tissue culture, and, later, Ernst's part with Burrows in the effects of radiation on growth-promoting and cell-differentiating fluids. It will be remembered that Burrows demonstrated a growth-promoting substance he called "archusia," and an antagonistic cell-differentiating fluid called "ergusia." According to Harris, the former, archusia, is similar to water-soluble vitamin B; the latter, ergusia, is similar to fat-soluble vitamin A, while vitamin D is a fat-soluble calcium-distributing agent in the presence of calcium phosphate. Archusia and vitamin B cause the cartilage cells to proliferate; ergusia and vitamin A bring about differentiation of cells into true bone cells, while vitamin D is responsible for the mineralization. But surely all these three agents should be in proper balance, or the one might gain ascendancy over the other and abnormal changes would result. Some more or less permanent disturbance of the origin of one or more of these growth-

promoting and dfferentiating agents on the left side, by the radiation, may have been responsible for the changes noted in the tissues of this child. It could hardly be a central agent, such as the pituitary for instance, for interference with a general internal secreting gland would have affected both sides of the body. It must have been some tissues in the direct field of irridation on the left side. Harris quotes a case of tuberculosis of the knee joint in a youth 17 years of age, in which the femur on the diseased side became an inch longer than its fellow. Humphrey's explanation of this is: "We suppose the disease in the lower part of the shaft of the femur acted as a stimulus to preternatural activity of the growing processes in the epiphysial line."

Harris states that "it would appear that a low-grade tuberculous infection or increased resistance, on the part of the patient, might lead to overgrowth in the bones, whereas severe infection or lowered resistance might lead to arrest of growth."

He refers to a case of tuberculosis of the knee of five years' duration, in which the diseased limb was 2 cm. shorter than its fellow. He shows by roentgenograms that there was diminished growth in the length and the diameter which was not localized at the ends of the bones adjoining the knee, *but was shared by the distal extremity of the tibia*. He says this must not be interpreted as evidence of decreased interstitial growth; it is a direct result of the fact that the *rate of proliferation* of the cells in the cartilage columns at the epiphysial line is less on the diseased side than on the sound side. That may be true, but why should the rate of proliferation of the cells in the cartilage columns be less on the whole side, when the diseased process involved only the knee? Any toxins from the tuberculous process absorbed by any part of the circulatory system should affect the whole body.

There seems to be an analogy here between the effect of a local disease process involving cartilage and the roentgen effect on cartilage. Are the effects noted in the two cases the result of insult to the local distribution of the sympathetic nerve which normally would have control over the differentiating and growth-promoting activities of these cells?

Honor B. Fell (quoted from Harris) has succeeded in growing "in a small tissue chamber the early limb buds of a chick. The isolated fragment from the proximal part of the limb grows and differentiates in the tissue chamber. The mass of mesenchyme grows, the cartilaginous femur appears with well-demarcated extremities, and the cartilage cells become oriented to form columns of cells in the region of the epiphysial growth—cartilages. The matrix of the cartilage calcifies, new bone is formed, and the resulting femur bears a striking resemblance to the normal in its general configuration and histologic structure." This was apparently accomplished by using a properly balanced embryonic nutritive fluid. It would be interesting to repeat this experiment by subjecting the nutritive fluid to short wave radiation before it is used.

CONCLUSIONS

Whatever the mechanism, it is apparent from our experience with this case and the reports of Haenisch's case, that:

(1) Young growing skin, soft tissues, and growing cartilage may be retarded in their growth for at least several years, and their hereditary characteristics may be changed by intensive more or less homogeneous short wave radiation.

(2) That, while one side of the pelvis and the upper half of the thigh only so irradiated may suffer such changes, the tibia and fibula of the same side, which were not in the path of the rays, may undergo a similar retardation of growth.

(3) That retarded poorly differentiated bone, resulting from irradiation, may have a very weak resistance to infection for several years after the irradiation.

(4) That great care should be taken in the radiation treatment of children, particularly infants. Only very light treatments should be given to young children in any disease, except when, as in this, life is at stake and the disease requires heavy radia-

tion. In such cases as the latter the parents should be advised of the probable retardation of growth and differentiation of tissues, not only in the part irradiated, but in the most distal part of the same side.

DISCUSSION

DR. W. S. LAWRENCE (Memphis): I wish to ask if these were private or ward cases, and just to what extent their rebellion went at the height of the reaction caused by the treatment. I would also like to ask if any biopsies were done—say, a month or two after the treatment to see what the final result might be; whether there were any prospects or possibilities of relapse a little later.

I would judge that the Doctor's economic statement was a little low. The actual time of running the tube may not have cost more than the amount stated, but the total overhead for that amount or that number of r would, I think, be rather excessive.

DR. MAX CUTLER (Chicago): I would like to ask Dr. Stevens what the dosage was on the case he treated.

DR. STEVENS: The child received something over 800 r during 11 days in a preliminary series in November, 1929. In January, 1930, during a period of 21 days she received something over 900 r.

DR. CUTLER: What was the child's age?

DR. STEVENS: Four months when we began treatment.

DR. CUTLER: I think that you have made a very interesting observation. I have a similar problem at the present time with a child four years of age in whom a malignant tumor of the testicle was removed. In considering the question of prophylactic radiation, we are immediately confronted with the same problem. Shall we irradiate the operative site? How can we protect the opposite testicle? What is the castration or sterilization dose and shall we irradiate the retroperitoneal glands prophylactically? It brings up the same problem that Dr. Stevens has brought up.

I should like, also, to comment on Dr. Rathbone's paper.[1]

It is my belief that you are not taking quite enough credit for some of these cases that you have called basal-cell carcinoma. Several of the cases that you have cured are clearly adenocystic epitheliomas, and they are far more radioresistant than basal-cell carcinomas.

Finally, I would like to congratulate Dr. Rathbone upon his very important contribution. I do not know of any group of cases in which such large doses of radiation have been used on lesions which have been irradiated previously. It is important to know to what extent a complete irradiation can be executed following previous incomplete radiotherapy. Most radiologists would have hesitated to administer so much radiation to lesions that had been subjected to previous treatment. Dr. Rathbone has given us some very valuable information on this subject.

DR. CHARLES V. GENOWAY (Boise, Idaho): I would like to ask the Doctor what milliamperage he used.

DR. LAWRENCE: May I add one question which I forgot to ask? Have you had any trouble with radiation neuritis or neuralgia in these extreme doses? I recall one case myself that I thought I overtreated. The lesion was all gone. It was in the region of the parotid gland. Nothing was wrong with the skin—everything looked fine—there was no lump left, and I thought the patient was well. A few weeks later—or a month or so later—the patient developed extreme pain in that region—neuritis or neuralgia or something of the sort.

I have read of a good many cases of extreme pain in the axillary nerves from the implantation of radium too close to the nerve, and this, it seems to me, would be about as much radiation as you would get from interstitial radiation by radium.

[1] The Treatment of Epithelioma Involving Cartilage Using 220 K.V.P. and Heavy Filtration. E. A. Merritt and R. Rhett Rathbone, RADIOLOGY, 1935, **24**, 701–707.

DR. WILLIAM H. SARGENT (Oakland, Calif.): For several years I have been using unfiltered radiation in doses of from 4,000 to 6,000 r in the treatment of superficial malignancies. When treating lesions about the mouth and nose, severe reactions will occur upon the underlying mucous membrane of the cheek, gum, or tongue or in the nasal passages unless these structures are protected. I should like to ask the Doctor if he has noticed similar reactions from the doses of heavily filtered radiation.

Regarding the malignant involvement of cartilage, it has been my observation that if the perichondrium only on one side of the cartilage has been destroyed, healing is extremely difficult to obtain, even though the malignancy has been destroyed. A chronic inflammatory condition or perichondritis develops around the denuded area of cartilage which slowly spreads and often becomes very painful. A recurrence may be suspected and further treatment given, which only adds to the difficulty. Complete removal of the denuded and inflamed area of cartilage, either by excision or cautery, seems to be necessary to obtain a complete healing.

DR. STEVENS (closing): I was in Washington last February [1933] when I first saw some of these cases demonstrated, and I was so impressed with the work that I asked them to present it at this time.[2]

There are two or three points I would like to emphasize.

First of all, I think this work seems to demonstrate what has generally been denied by physicists and biologists for some time—that there is a selective action of x-rays according to the wave length. I do not say that Dr. Rathbone's results prove such a theory, but they present more evidence in favor of such a conception.

Also, that the importance of, first of all, getting rid of as much of the infection as possible before beginning to treat any carcinoma with radiation is an important point that was originally brought out by Regaud and his collaborators. Their results show the importance of carrying out that technic. Infected tissue is very apt to slough and to give trouble.

Another point is that we must give these cases very large doses of radiation over a long period of time in order to get results.

DR. R. RHETT RATHBONE (closing): Of the 14 cases I presented,[2] 11 were private patients and three were clinic cases. That is about the relative percentage. We give private cases the same dose we give clinic patients.

As far as the pain is concerned, we think that the striking difference between this highly filtered radiation and lightly filtered radiation is the mild reaction, and the small amount of pain is well controlled by nupercainol ointment. As Dr. Stevens pointed out, we have to be scrupulously careful about keeping the treated areas clean until the lesion is entirely healed, to avoid infection.

As to biopsies taken two or three months after treatment, we have taken no biopsies, as the lesions all healed or looked perfectly healthy except in one case—a year afterward—in which we suspected that we had not completely eradicated the lesion.

We used 20 milliamperes in all cases.

As to neuritis following this treatment, we have had no evidence of the radiation producing nerve injury.

I am very glad Dr. Cutler called our attention to adenocystic basal-cell carcinoma. In reviewing some of the pathologic slides with Dr. J. W. Lindsay, our consulting pathologist, he stated that several of the cases were adenocystic basal-cell carcinoma.

As to the accuracy of the dose, I did not mention that we have two Victoreen "r-meters," and check one against the other. One of them was checked at the Bureau of Standards this Fall, so we are certain we are giving these tremendous doses.

As for the reaction on the mucosa in treating lesions about the mouth, we do get

[2] See paper by Dr. E. A. Merritt and Dr. R. R. Rathbone in RADIOLOGY, June, 1935, **24**, 701–707.

the usual diphtheric membrane, which seems to be more painful than the skin reactions. To protect the tongue and alveolar mucosa we place a millimeter of lead covered with red dental rubber between the teeth and the cheek.

The total number of cases treated so far is small, but the rapid, relatively painless healing of these lesions involving cartilage is most gratifying and the results are superior to the methods we have used previously.

FURTHER DISCUSSION OF THE RELATIONS OF THE ANTRUM AND CAP TO THE GALL BLADDER AS FACTORS IN EMPTYING THE GALL BLADDER[1]

By NATHAN B. NEWCOMER, M.D., *and* ELIZABETH NEWCOMER, M.D.,
Denver, Colorado

THE function of the gall bladder is to receive, store, and concentrate the bile, to act as an equalizer of pressure in the biliary system, and to deliver the bile periodically into the duodenum during early digestion. The gall bladder empties through the cystic duct into the common duct, and thence into the duodenum. It may empty normally in small quantities when the stomach is empty.

In routine visualization of the gall bladder, we noticed that its location varied within wide limits in the different types of habitus, and that the extremes were more apt to have gall-bladder disease. When a barium meal was given, the position of the pyloric antrum and duodenal cap varied in a similar manner. Often, we visualized the gall bladder by the dye test and the stomach by the barium meal at the same time.

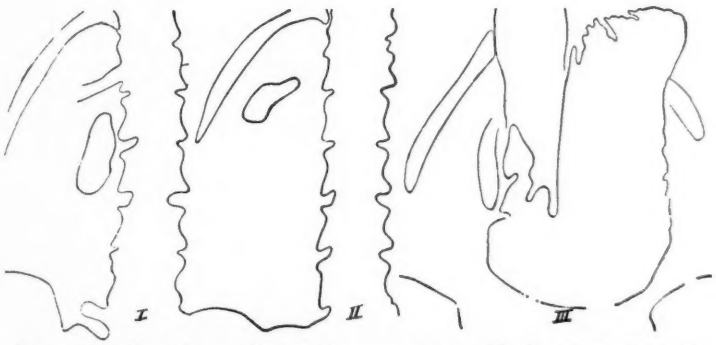

Fig. 1. Tracings of x-ray films of the same person: (I) visualized gall bladder, stomach empty; (II) visualized gall bladder, stomach filled with solid meal (note change in shape and position after eating a solid meal); (III) visualized gall bladder, stomach filled with barium and buttermilk. Note that the gall bladder lies nearer the mid-line and lower with the liquid meal than with the solid meal.

Before the epochal discovery by Graham and Cole, which allowed visualization of the gall bladder in man, our knowledge of the location and behavior of the human gall bladder in the living was limited. We knew that a flattened or crescentic indentation shown on the duodenal cap or stomach probably meant a pathologic gall bladder, and also that a long, narrow, rigid antrum which did not expand during peristalsis generally indicated gall-bladder pathology. Also, that overweight and underweight, pregnancy, fibroids, and abdominal tumors predisposed to gall-bladder pathology.

Normally, the gall bladder, antrum, and cap were in close contact; generally, when they were not, pathology was present in the gall bladder. Routinely, we made a mark on the patient's right side half way between the crest of the ilium and the ribs and half way between the vertebral column and the side of his body, focussing through this point. The dye was given intravenously and a film taken in six hours, before eating. A second film was taken an hour after eating. We noticed that if the gall bladder was normal it moved upward and outward from one to two inches after eating, and had a flattened or curved indentation on the side next to the antrum and cap, particularly during a peristaltic wave of the

[1] Read before the Midsummer Radiological Conference in the Rocky Mountains, sponsored by the Denver Radiological Club, Aug. 28–30, 1935.

antrum. If the gall bladder did not move upward and outward, it was practically always diseased and would not empty even

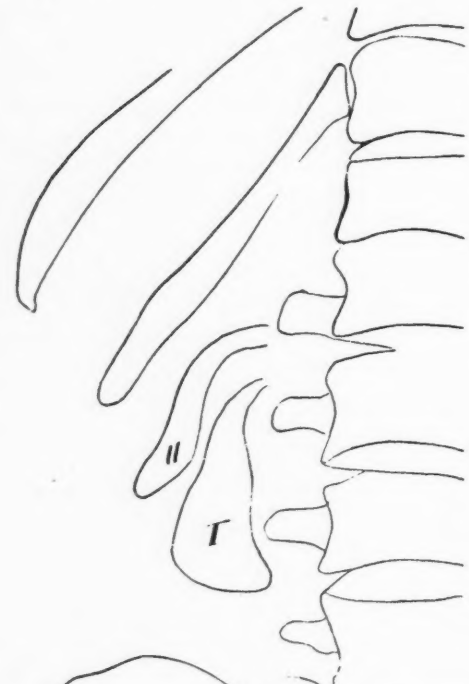

Fig. 2. Tracings of x-ray films, showing the change in shape and position of the same gall bladder, (I) before eating, (II) after eating.

in 24 hours. If there was a crescentic indentation on the cap, the gall bladder was diseased. Occasionally, a gall bladder would not visualize before eating but would visualize immediately after eating and empty in 24 hours. Many gall bladders visualize, are light in density, and will not empty in 24 hours; others visualize, are normal in density, but will not empty in 24 hours.

An effort to explain these variations led us to study the anatomic relations of the stomach, duodenum, and gall bladder, and also to study the literature as to the factors concerned in the emptying of the gall bladder.

There were a great many confusing and conflicting ideas as to the factors concerned and especially in regard to the following: muscular development of the gall bladder and the efficiency and nature of its contractions; elastic recoil; respiration; engorgement of the liver; dilution and interchange of bile in the gall bladder and reciprocal action with the sphincter of Oddi; a gall-bladder hormone, and gastric and duodenal peristalsis. A short review of the known facts is as follows:

McMaster and Elman state: "The discharge of bile into the duodenum may be thought of as chiefly dependent upon three factors: the tonus of the muscles about the lower common duct, the activity of the gall bladder, and the pressure of the bile secretion."

The sphincter of Oddi at the outlet of the common duct and the intramural mechanism interpose a moderate barrier to the continuous passage of bile into the duodenum, thus allowing the gall bladder to fill. When the action of the sphincter is destroyed by inserting a cannula or by other means, the gall bladder does not fill; when the gall bladder is absent or occluded or removed by surgery, the secretory pressure overcomes the sphincter and bile passes continuously into the duodenum. Without this sphincter, there would be little or no pressure in the biliary tract.

There would be no pressure in the biliary system if it were not for secretory pressure. The secretion of bile is more or less continuous but is more active during gastric digestion. The gall bladder concentrates the bile by removing the liquid constituents between periods of digestion, and thus reduces the pressure due to secretion below the threshold of the sphincter of Oddi.

The resistance to the passage of bile into the duodenum varies with the tone of the sphincter, which may be increased or decreased by a great many different things. The sphincter is a type of involuntary muscle subject to nerve control. It is also subject to involuntary muscle stimulants and depressants; to mechanical, chemical, and local stimulants. It is affected by the general body condition; duodenal peristal-

sis; mechanical distention by air, water, food, etc.; by the amount of pressure in the connected with the gall bladder, suggesting a discharge of bile contents.

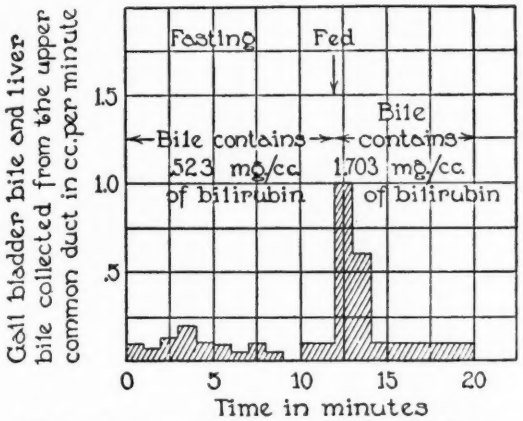

Fig. 3. Food as a stimulus to the discharge of bile from the gall bladder. Bile was collected from the upper common duct, draining both liver and gall bladder. The gall-bladder connections had been left undisturbed. When food was given, a large amount of viscid and highly pigmented bile was voided, practically at once. The differences in the amount and nature of the bile collected point to a discharge of bile from the gall bladder. (This graph is taken from Philip D. McMaster, M.D., and Robert Elman, M.D. Jour. Exp. Med., 1926, **44**, 173.)

bile duct system, and the presence or absence of food in the stomach and cap.

In regard to secretory pressure and pressure in the common bile duct and gall bladder, we quote further from McMaster and Elman from their experimental work on dogs. These experiments are quite convincing and generally quoted.

"To determine secretory pressure, it is necessary to exclude the gall bladder as absorption of the fluids by the gall bladder occurs rapidly; in dogs, it has been found by various observers to be from 200 to 320 mm. of bile when all outlets have been excluded. The rate of secretion does not vary until the maximum pressure is reached, when it stops at once.

"With the gall bladder excluded, and while the bile was being collected, the animals were allowed to eat bread, milk, and meat mixture for from two and one-half to three minutes. No change in the rate of secretion occurred in the first 5 to 15 minutes, then a gradual progressive increase occurred, but the amount of bile secreted returned to normal in about 45 minutes.

"With the gall bladder undisturbed, and immediately after the first swallows of food, an abundant gush of far darker and more viscid bile suddenly flowed into the graduate

"From 60 to 70 mm. of pressure causes bile to enter the gall bladder in the anesthetized dog and 100 mm. in the unanesthetized dog. The resistance to the passage of bile through the common duct sphincter in the normal animal fed 4 to 12 hours previously is sufficient to support a column of bile from 100 to 120 mm. in height, and in the fasting animal from 250 to 300 mm. high. The resistance is lowered from 50 to 80 mm. immediately after taking food and later during digestion.

"Food was given to a dog for two minutes after it had been fasting 30 hours. Five to 10 seconds after swallowing, the bile column began to rise, and in 45 seconds bile was forced into the collecting graduate against the 200 mm. of pressure and continued to flow for 45 seconds more. The animal was again allowed to eat for two and one-half minutes, consuming 150 grams. Almost at once the bile column rose to over 200 mm. and returned again slowly to its previous level, until 8 minutes later it had gone to 115 mm. and there it remained. Seventeen minutes later, food was again offered, and the bile rose above the 250 mm. level.

"In these experiments, there was no sudden gush of bile from the liver, the increase in bile secretion after feeding being very gradual, but the abrupt rise in the column of bile in the manometer connected with the gall bladder

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 4. A gall bladder visualized by the intravenous method at six hours. Note the relation of the gall bladder to the liver, and the oblique angle of the lower border of the liver. Note also the shape of the gall bladder and the pendulous position, before a meal is taken.

Fig. 5. The same individual, 15 minutes after a liquid meal. Note the relation of the antrum and cap to the gall bladder. Note the flattening of the gall bladder during peristalsis. This is not a contraction; it is the direct pressure of the antrum and cap against the gall bladder.

Fig. 6. The same individual, 20 minutes after a liquid meal. The gall bladder appears relaxed in the absence of peristalsis of the antrum.

could therefore have been due only to pressure within the viscus.

"In several experiments, the rhythmic recurrence of abrupt increases in pressure within the gall bladder in the absence of any further ingestion of food rules out the possibility that a generalized increase of intra-abdominal pressure was the direct cause of the phenomenon."

The secretion of bile is increased greatest by proteids, less by fats, and not at all by carbohydrates. It is also increased by certain drugs and other substances (secretin).

MUSCULAR DEVELOPMENT OF THE GALL BLADDER AND THE EFFICIENCY AND NATURE OF ITS CONTRACTIONS

Gray's Anatomy states:

"The fibro-muscular coat, a thin but strong layer forming the framework of the sac, consists of dense fibrous tissue, which interlaces in all directions, and is mixed with plain muscular fibers, disposed chiefly in longitudinal direction, a few running transversely."

Characteristics of plain, smooth, or involuntary muscle are as follows, quoted from Starling.

"The physiologic properties of plain muscle differ with its source. Plain or smooth muscle is distinguished from voluntary muscle not only by its histologic structure, its chemistry, its innervation, and its physical properties, but especially by the phenomena of independent tonus and rhythmic contraction.

"In case of smooth muscle, there is a double nerve supply, one variety being motor and the other inhibitory.

"The physiologic significance of the double nerve supply is evident from the fact that, even when deprived of all nerves, plain muscle may exhibit either sustained spontaneous contractions, known as tonic, or else intermittent rhythmic contractions, so that control of both contraction and relaxation is essential.

"The strength and frequency of these rhythmic contractions vary much according to conditions; in some types of plain muscle, they are quite regular, frequent, and powerful, whereas, in other cases they are slow, often irregular, and of variable or negligible amplitude.

"Plain muscle also reacts to chemical stimulation. Many drugs such as eserine, salts of lead and barium, histamine, acetyl choline, pilocarpin may cause contraction. The action of these drugs varies from organ to organ, and some of them such as eserine, barium salts, and perhaps pituitrin appear to act directly on the muscle cells, while others, as adrenaline, exert their action on the accompanying nerves or their endings. Accordingly, adrenaline may cause either relaxation or contraction.

"Smooth muscle is also very sensitive to mechanical stimulation, and the most important form of this is that produced by tension. The effect of increasing the tension on smooth muscle may be twofold: causing in the first

place extension, and, in the second, excitation with increased contraction.

"A peculiar property of plain muscle is that a stimulus (electrical or mechanical), which, when applied to the relaxed muscle, causes a contraction, will, when applied to the tonically contracted muscle, often provoke a rapid relaxation, and *vice versa*. This also holds true for nerves supplying the plain muscle, and may be the cause of rhythmic contractions when the muscle is slightly stretched."

The gall bladder contains smooth muscle and elastic tissue, and is subject to nervous control, but fills and empties when completely denervated. Like other involuntary muscle, it is affected by certain drugs and electrical and mechanical stimulation. It is subject to increases of pressure exerted by adjacent organs, as the liver, stomach, intestines, respiratory movements, etc. Also many drugs which increase the secretion of the bile will have a definite effect on the tension of the gall bladder.

CONTRACTIONS OF THE GALL BLADDER AS SEEN IN ANIMALS AND MAN (TAKEN FROM IVY)

In Animals.—"Genuine contractions have been recorded from the gall bladder *in situ*, in both anesthetized and unanesthetized animals, chiefly in the dog, and from 'strips' of the gall-bladder wall.

"The motility of the gall bladder in the dog is of two types: first, a tonic contraction of the musculature which causes a prolonged increase in intra-gall-bladder pressure, lasting from 5 to 30 minutes or more; and second, a tonus rhythm, in which the gall bladder contracts and relaxes at a rate of from two to six times per minute. In each type, the musculature as a whole or a portion of it may contract. The tonic contraction may lead to a maximum rise in intra-gall-bladder pressure of from 20 to 30 cm. of bile with the cystic duct obstructed."

Winkelstein and Aschner state: "The musculature of the gall bladder displays tonus variations but seems to possess little contractile power. No evidence was found of spontaneous contractions of the gall bladder in the dog either under anesthesia or when fully recovered."

Okada and Levine both record rhythmic contractions of the gall bladder.

Sachs, Howard, and Barry state: "That gall-bladder contractions exist can hardly be questioned; it is hard to believe that it alone can account for expulsion of the gall-bladder contents, and, in our opinion, it is only one of the factors which assist in this process." Freeze concluded that the maximum force of contraction of the bladder does not much exceed the maximum secretion pressure as determined by Heidenhain.

A careful study of the literature leaves no doubt that the gall bladder contracts, but there is considerable skepticism among many competent observers as to the efficiency of this contraction in emptying the gall bladder. Of necessity, any expansile vesicle must have power of contraction, otherwise it could not adjust itself to its variable content. If the sphincter of Oddi is sufficiently relaxed, the contraction of the gall bladder might aid in evacuation. It is extremely doubtful if the contractions exert enough force to overcome the normal tone of the sphincter and empty the gall bladder in the manner and the time at which it is known to empty.

In Man.—Very few observers claim to have seen actual contractions of the exposed gall bladder in man.

Moynihan states: "I have watched the gall bladder many hundreds of times during operation, and have never seen anything approaching a tonic or peristaltic contraction. Very rarely one does see evidence of life."

Ivy cites Bassler, Luckett, and Lutz as not observing contraction of the gall bladder at laparotomy after the instillation of magnesium sulphate into the duodenum. He quotes Pribam as observing a "distinct" contraction associated with evacuation after instilling Witte's peptone into the duodenum. He also quotes Kalk (using the method of intra-abdominal endoscopy and injecting pituitrin subcutaneously) as observing the gall bladder gradually decrease to one-half its original size, manifesting tonic contraction but no sudden contraction or peristaltic waves.

Matsuo reports two cases in which the abdomen was open and the gall bladder under direct observation. In the one case,

in which the duodenal tube was inserted two hours before operation, the abdomen was opened under local anesthesia and the gall bladder was observed as large as a goose egg. $MgSo_4$ was instilled into the duodenum through the tube. He did not see the so-called contraction, nor did the gall bladder collapse like a balloon from which the air was released, as in the case reported by Dr. Sachs. The gall bladder decreased to one-fourth its size in an instant after instillation of magnesium sulphate.

In the second case reported by Matsuo under the same conditions in which, after the gall bladder was exposed and when bile ceased to flow, $MgSo_4$ was introduced. The bile did not flow, as the olive was not in place. He replaced the tip and then introduced 35 c.c. of a 1 per cent azorubin S solution into the gall bladder and red bile ran out. He then instilled $MgSo_4$ through the tube and 45 c.c. of bile ran out in the first five minutes, 42 c.c. in the next five. At this time, the gall bladder became small although nothing like a contraction could be observed.

This is not a very convincing array of evidence of an actively contracting gall bladder evacuating its contents through the intrinsic action of its own musculature. The instillation of $MgSo_4$ into the duodenum undoubtedly lowers or destroys the tone of the sphincter, enabling the gall bladder to evacuate because of lack of resistance of the sphincter instead of by active purposeful muscular action of the gall bladder.

DISCUSSION OF TERMS USED

Much confusion has arisen in the gall-bladder literature because of the use of inexact terms by some authors. The term "contraction of the gall bladder" is often used when evacuation or emptying of the gall bladder is all that has occurred; again in some cases, the term "contraction" is used when decrease in size or a collapse of the gall bladder is meant. Some authors reason that the changes in size and shape of the gall bladder seen in x-ray films can only be due to contraction and consequently term the changes, "contractions." Some do not differentiate between general changes in intra-abdominal pressure and local pressure. Pressure fluctuations in the gall bladder registered by different methods are often termed "contractions." It is often necessary, when reading an article in which some author is quoted, to secure the original article to determine exactly what is meant.

DISCUSSION OF VARIOUS FACTORS WHICH CAUSE EVACUATION OF THE GALL BLADDER

Experiments by many establish the fact that various apparently unconnected factors will at least partially empty the gall bladder, some of which are enumerated. Fear, anger, excitement, smell of food, hunger pains, tube inserted into the stomach or duodenum, breathing, vomiting or straining, peristalsis of the stomach and duodenum, shaving the legs, skin incisions, intravenous of blood, cross-circulation, insulin, water by mouth, and various substances introduced into the duodenum through a tube; also, $MgSo_4$ by way of the stomach, or into the duodenum through the tube, besides many other drugs. Ivy reports that the hormone "cholecystokinin" will empty the gall bladder. But above all, food in the stomach is the normal method of emptying the gall bladder. Many claim that fats are essential, but a normal meal will empty a normal gall bladder (Figs. 19 and 20).

EFFECTS OF FOOD

The ultimate function of the gall bladder is to deliver the stored and concentrated bile into the duodenum early in digestion. Boyden discovered that egg yolk and cream would completely empty the gall bladder, and based most of his experiments on a meal of five egg yolks and half a pint of cream. However, a normal gall bladder should empty after a normal meal of meat, bread and butter, potatoes, etc. We have seldom if ever used any other meal for emptying the gall bladder since we started to use the dye test except for experimental purposes. We believe this is a better test

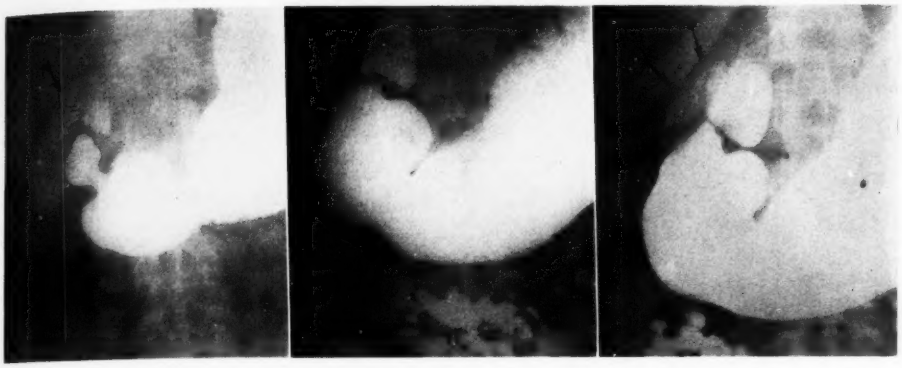

Fig. 7. Fig. 8. Fig. 9.

Fig. 7. The same individual as in Figures 4, 5, and 6, 25 minutes after a liquid meal. The gall bladder is "relaxed." The peristaltic wave of the antrum has not contacted the gall bladder.

Fig. 8. The same individual after a solid meal was given. Note the increased distance of the antrum to the right with a solid meal, and the more intimate contact of the antrum and cap with the gall bladder. Also the marked reduction in size of the gall bladder as the antrum and cap press it against the liver.

Fig. 9. The same individual 45 minutes after the solid meal. Note how much larger the antrum is, and how much farther it is pushed to the right with a solid meal than with a liquid meal.

of the ability of the gall bladder to empty under normal conditions than the egg yolk and cream mixture.

Great credit should be given Dr. Boyden for his persistent, open-minded, and careful investigation of the gall-bladder problem in man and animals. We are quoting a short review of the results of his experiments. He divides the reaction of the gall bladder to foods into four periods: "(1) initial response; (2) the two-minute pause; (3) the principal period of discharge; (4) succeeding phases of contraction.

"*The Initial Response.*—Perhaps the most striking feature of the reaction of the gall bladder to food is the very short latent period of contraction; 14 out of 17 patients showed a marked diminution of volume within the first two minutes after food entered the mouth. Since fluoroscopic observation indicates that the 'head of a meal' of egg yolk passes the pylorus a few seconds after deglutition, the latent period of the human gall bladder is therefore established as approximately one minute after egg yolk enters the duodenum. (McMaster and Elman showed the latent period for the gall bladder of the dog to be exactly the same.)

"A second observation that can be made about this first period of contraction is that the diminution of volume in the first two minutes is usually greater than that of any subsequent two minutes—an average of 5.1 c.c. as compared with 3.1 c.c. in the ten cases.

"*The Two-minute Pause.*—At the end of the first two minutes, the descent of the curve is abruptly checked and is not resumed again until at least two minutes later. This is a very characteristic and significant feature in the emptying of the human gall bladder, as it has occurred exactly at this point in 12 out of the 17 cases.

"*The Principal Period of Discharge.*—By this phrase is meant that portion of the first phase which results in the greatest discharge of bladder bile. It follows immediately after the two preliminary features already noted—'initial response, and the two-minute pause,' and ends anywhere from 16 to 60 minutes *postcibum*. In the last 17 cases, its average duration was 32 minutes, during which time the contents of the gall bladder (excluding the neck) was reduced approximately three-fourths of its volume. From these data it must be apparent that the first phase is the most significant portion of the cycle of emptying and filling, for by means of this a large amount of concentrated bile is poured into the duodenum during the first part of a meal.

"*Succeeding Phases of Contraction.*—Following the termination of the first active phase, the gall bladder is generally quiescent for a short period, varying from 5 to 45 minutes. Then comes the second phase of contraction, frequently followed by several alternating periods of relaxation and contraction, until eventually the gall bladder is emptied.

"It may be noted that the phases of contraction subsequent to the first are more or less irregular and not sharply defined. Moreover, they are less important, since one-half to three-

fourths of the contents of the gall bladder has already been discharged. Since the organ is no longer distended, the expulsion of bile is much slower, especially toward the last. It sometimes happens that the gall bladder is sometimes emptied by the first or second phase of contraction but in the majority of cases it takes three or four phases.

EVIDENCE SUGGESTING REGULATORY ACTION ON THE SPHINCTER MECHANISM AT THE OUTLET OF THE COMMON DUCT IN MAN

"In any discussion of the mechanism of the flow of bile, two factors are of prime importance: the force which expels the bile from the gall bladder, and the method by which the flow of bile is regulated. Since the evidence now seems conclusive that the musculature of the gall bladder is responsible for the expulsion of the contents of the organ, it is possible for the flow of bile to be regulated in only two ways—either exclusively through the activation or inhibition of this expelling musculature, or by the addition to this of a supplementary mechanism which controls the flow of bile at the outlet of the common duct.

"*The Two-minute Pause.*—A second line of evidence, suggesting a dual control of the flow of bile, is offered by the existence of the peculiar irregularity in the curve of the first phase of contraction, which has been previously designated as the 'two-minute pause.' When it became clear that this was a fairly constant feature, the question arose as to why the flow of bladder bile should be temporarily checked at the end of the first two minutes. The matter was further complicated by the observation that the *shape of the gall bladder* during the 'two-minute pause' *did not indicate relaxation*, but rather *continued contraction*. Coupled with this was the interesting fact that the reduction of gall-bladder volume was greater in the first two minutes than any subsequent two minutes. The implication was that the irregularity in the curve was due to the action of the duodenal sphincter, and not to the gall bladder; that, following the ingestion of food, the orifice of the common duct was suddenly opened, permitting the gall bladder to fill the extra-hepatic duct system without hindrance, and that, two minutes later, renewed closure of the orifice checked the flow of bile from the gall bladder temporarily, even though the latter continued to contract.

"Simultaneously with the ingestion of food, there is a drop in the resistance of the sphincter. Approximately a minute later, the gall bladder begins to contract. As a third step in the sequence of events, the resistance offered by the sphincter suddenly increases, beginning two minutes after the ingestion of food, and continuing until it is greater than the force exerted by the gall bladder.

"The striking agreement of these data with the observations recorded by the writer seems to afford the most satisfactory basis for interpreting the contraction curves of the human gall bladder."

He cites a case in which small amounts of egg yolk were injected directly into the duodenum at intervals.

"After each injection, the gall bladder immediately 'contracted.' This series emphasizes three facts. First, that the initial effect is greater when egg yolk is introduced directly into the duodenum than when taken by mouth; secondly, that a food stimulus is most effective when applied to a distended gall bladder, and thirdly, that the mechanism of contraction is a trigger mechanism set off by a variety of fatty foods, and that the entrance into the intestine of each dose of an effective food results in a single phase of emptying which is immediately followed by filling. Incidentally, it shows that one egg yolk is not sufficient, but that enough must be eaten to insure sufficient spurts of yolk-laden chyme to induce the number of successive phases required to empty the gall bladder, and the right kinds of fatty foods must be chosen to completely empty the gall bladder."

SPHINCTER TONE

There is no question but that the tone of the sphincter is an important factor in emptying the gall bladder. In a fasting dog, the sphincter will support a column of water 250 to 300 mm. in height; in the normal animal fed 4 to 12 hours previously, 100 to 120 millimeters. After taking food and again later during the process of digestion, the resistance of the sphincter is lowered from 50 to 80 millimeters.

Many substances injected directly into the duodenum relax the sphincter. Several factors enter into their action. Boyden states:

"The Rehfuss tube in the stomach caused marked emptying of the gall bladder, 16 to 18 c.c. The smelling of food, distention of the duodenum with air, and drinking of water, all produced the 'initial response' induced by ingestion of food. Injecting 30 c.c. of HCl, 50 to 75 degrees acidity, into the duodenum produced immediate contraction and diminution of the gall-bladder volume followed by filling. $MgSO_4$, $MgCl_2$ and Na_2SO_4 injected

Fig. 10.

Fig. 11.

Fig. 12.

Fig. 13.

Fig. 10. A visualized gall bladder. Note its position and shape when the stomach is empty.

Fig. 11. Note the change in size, shape, and position of the same gall bladder after the administration of a solid meal. This gall bladder was entirely empty in 24 hours. Note the shifting upward and to the right, due to the pressure of the filled stomach. Note the change in shape which is due to pressure, and not to a contraction of the gall bladder.

Fig. 12. A visualized gall bladder by the intravenous method at six hours (before eating). Asthenic habitus. Note shape and location of the gall bladder.

Fig. 13. The same gall bladder after administration of a solid meal. Note that there is practically no change in size, shape, or position. It does not move upward and outward after eating. This gall bladder did not empty in 24 hours.

into the duodenum, in 5 out of 8 cases emptied the gall bladder two-thirds within 40 minutes."

Obviously as Boyden says,

"They also open the intestinal orifice of the gall bladder or the bile could not escape."

Matsuo (in man) with the abdomen open, the gall bladder exposed, and the duodenal tube in place, after instillation of 40 c.c. of 33 per cent $MgSO_4$, states: "Two minutes afterward bile began to flow out; 45 c.c. was recovered in the first five minutes, and 42 c.c. in the next five minutes. At this time the gall bladder became small, although nothing like contraction could be observed to be taking place." This indicates a relaxation of the sphincter.

Ivy and Oldberg report on contraction of the gall bladder with HCl in the duodenum: ten experiments with the cystic duct clamped and the gall bladder cannulated under barbital anesthesia. Ten to 40 c.c. of N/10 HCl were introduced into the duodenum with needle and syringe. They observed contraction of the gall bladder (judged by a rise of bile in the cannula) in every instance. The minimal quantity needed to elicit a response was 15 cubic centimeters.

"The injection of the following substances into the duodenum of the dog caused the gall bladder to contract with the animal under light barbital anesthesia. Fifteen to 40 c.c. of N/10 HCl, 30 c.c. of butter, digested egg yolk, cream and olive oil, 0.5 per cent butyric acid, and 5 per cent soap solution. Undigested olive oil, egg yolk, and cream were ineffectual."

We quote from Winkelstein and Aschner as follows: "Various agents (notably substances present in gastric chyme and $MgSO_4$), when placed on the papilla of Vater, lessen somewhat the tonus of the sphincter of Oddi but usually not more than one-fifth to one-sixth of the original figure."

Certain drugs have a depressant action on the sphincter. All drugs that cause a fall in blood pressure cause the gall bladder to empty.

Winkelstein and Aschner say further: "Of the drugs acting on the vegetative nervous system, atropin decreases and pilocarpin increases the tonus of both the gall bladder and the sphincter of Oddi. Adrenalin decreases the tonus of the sphincter."

Okada has shown that adrenalin relaxes

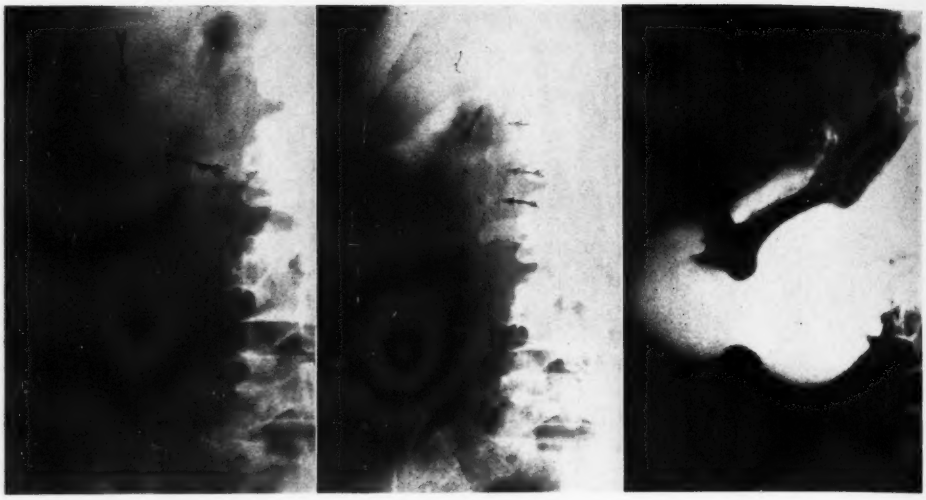

Fig. 14. Fig. 15. Fig. 16.

Fig. 14. This gall bladder is visualized very light in density, spherical in shape. It lies farther from the midline than normal.

Fig. 15. Same case as Figure 14, after taking a solid meal. The gall bladder shifted upward and outward. The cystic duct and common duct are visualized, which is very unusual. The gall bladder is flattened. Many investigators would state that this is due to a contraction of the gall bladder. We believe it is due to pressure of the antrum and cap.

Fig. 16. Same case. Shows the marked excursion of the stomach during peristalsis, and a markedly deformed cap. A comparison with film Figure 15, showing that the antrum contacts the gall bladder intimately, even in its abnormal location. This gall bladder does not fill normally until the cystic duct is straightened by the pressure of a solid meal. It empties in 24 hours in spite of its abnormal location.

the sphincter when injected intravenously. Boyden says the intravenous injection of adrenalin causes a greater expulsion of iodized oil from the gall bladder than any other agent. Alvarez says, "The action of adrenalin on the intestinal muscle is a purely depressant one."

Duodenal peristalsis is a factor in the control of the sphincter. Ivy states: "The relationship between the sphincter of Oddi and duodenal peristalsis has been described as follows by Giordano and Mann, and also by Puestow; bile may spurt from the papillary orifice without evident peristalsis, but if peristaltic waves are present, the outflow will occur with the peristalsis. The author (Ivy) interprets the evidence as strongly indicating that in those species which possess a gall bladder, the common duct possesses a special sphincteric mechanism, which is intimately co-ordinated with duodenal tone and peristalsis, but which may also function independently."

Starling states: "The sphincter of Oddi is competent to close the entrance of the bile duct into the duodenum when the pressure is low, and its action is further aided by contraction of the muscular wall of the duodenum itself."

Hunger pains are due to peristalsis and empty the gall bladder partially, as proven by Boyden.

The sight of food, hunger pains, the tube in the stomach or duodenum, water by mouth, air in the duodenum, egg yolks, $MgSO_4$, and HCl in the duodenum all empty the gall bladder partially. What are the principles underlying the actions of these varied substances on the sphincter of Oddi? Water, air, hunger pains, and $MgSo_4$ could hardly produce a hormone. They all produce peristalsis. Mechanical dilatation of the duodenum is a factor in most of them, and mechanical dilatation produces and increases peristalsis. That the amount of distention of the duodenum is a factor is

shown by Ivy's statement that from 15 to 30 c.c. will empty the gall bladder but that less than 15 c.c. will not do so.

intestinal tract is largely autonomous; that is, it carries within itself the mechanism essential to peristalsis."

Fig. 17.

Fig. 18.

Fig. 17. Visualized gall bladder in boy of 15 years. Intravenous method. Antrum and cap were deformed in the gastric films. This is the six-hour film, showing the gall bladder to be large, and light in density. It lies too near the mid-line. The seven-hour film (after eating) was not taken because of the patient's condition.

Fig. 18. Same case as Figure 17; 24-hour film, showing the gall bladder denser than at six hours. This boy had his gall bladder removed, with complete relief of symptoms.

Also Boyden states that 30 c.c. of one egg yolk and water injected into the duodenum will produce a greater initial effect than when taken by mouth. The fact that Winkelstein and Aschner noted only a slight reduction of sphincter tone when applying known sphincter depressants locally shows the absence of the additional factor of mechanical distention.

The passage of food into the duodenum also causes distention of the duodenum.

Alvarez states: "The duodenal cap tends to remain filled during the early stages of digestion." Also, "Most of the motor activities of the stomach and bowels are brought about and regulated largely by the internal pressure due to food." . . . Further: "It is clear then, that the gastro-

According to Starling, "The normal pressure in the duodenum is about 150 mm. of water, and the pyloric intragastric pressure 100 mm. during relaxation, and from 200 to 300 mm. during an intensive wave."

GASTRIC PERISTALSIS

Alvarez states: "In the human stomach, waves appear about once in twenty seconds. . . . . On the lesser curvature the amplitude is very small, and in the antrum it is large. . . . . The peculiar form of the contraction curve exhibited by the muscle in the pyloric antrum was observed even in the frog."

Quoting from Templeton and Johnson on hunger contractions: "Unlike the contractions in the upper portion of the stomach,

Fig. 19.

Fig. 20.

Fig. 19. Gall bladder visualized by the oral method. Buttermilk and barium were given. This negative was taken 15 minutes after eating. Gall bladder emptied in 29 minutes.

Fig. 20. Same individual as in Figure 19. Gall bladder visualized by the oral method. Cream, eggs, and barium were given. This negative was taken at 21 minutes. Gall bladder emptied in 1 hour and 15 minutes. Neither egg nor cream is necessary to empty the gall bladder. The commercial buttermilk contains scarcely a trace of fat.

that seen nearest the pylorus is not preceded by a rise in tone. The contraction is sudden and sharp."

Birch and Boyden state: "(1) Faradic stimulation of the pars pylorica of the stomach induces sudden contraction of the relaxed gall bladder and ejection of bile into the cystic duct. (2) Hunger contractions of the stomach occur synchronously with rhythmic contractions of the gall bladder, and probably account for the periodic emptying of the gall bladder during fasting."

We do not believe that reflex contraction of the gall bladder is the correct explanation, because repeated observers (including Boyden himself) state that the gall bladder will empty when food is taken, even after the gall bladder has been completely denervated.

MECHANICAL PROBLEMS AS FACTORS IN THE EVACUATION OF THE GALL BLADDER

A careful study of the mechanical features entering into the relations of the liver, gall bladder, cystic and common ducts, antrum of the stomach and duodenal cap, and the changes in their relations upon taking a meal, also the further effect on these relations during gastro-duodenal peristalsis, reveals the fact that they cannot help but produce localized increase in pressure on the gall bladder and play a distinct rôle in emptying it.

To get a proper understanding of the position and mobility of the liver, we will quote from Cunningham's Anatomy, "Posterior Area of the Parietal Surface" (p. 1117): (1) "The uncovered area of the right lobe is a considerable portion of the back of the right lobe—varying from one and one-half to two and one-half inches in width, and from three to four inches in transverse measurement—which corresponds to the interval between the two layers of the coronary ligament, and is devoid of peritoneum. Over this uncovered portion, which looks more inward than backward, the liver and diaphragm are in perfect contact, and are united by areolar tissue; here too is established a communication by small veins between the portal circulation of the liver and the systemic circulation of the diaphragm."

Piersol states the following in regard to the liver:

"The structures most potent in holding it in its proper position are, in the order of their importance: (*a*) the attachment of the hepatic veins to the inferior vena cava; (*b*) the coronary ligaments and the cellulovascular bands in and between its layers; (*c*) the fibrous tissue near the vena cava and on the non-peritoneal posterior surface of the right lobe; (*d*) the muscular wall of the abdomen (keeping the intestinal mass pressed upward beneath the liver), and (*e*) the lateral and 'suspensory' ligaments.

"Coincidentally, with the descent of the viscus, it undergoes a rotation of tilting forward so that its diaphragmatic surface is in contact with the abdominal wall."

This peculiar attachment allows a combination of upward and downward, and inward and outward displacement which is accompanied by rotation. The actual position of the liver and its attached gall bladder varies markedly with the habitus, from the sthenic to the asthenic type, changes in body weight, presence of ascites, pregnancy, uterine or ovarian tumors, etc. It undergoes a similar change in position in passing from an empty stomach to a full meal.

We wish to quote from Gray's Anatomy to call attention to the exact anatomic relationships of the antrum, pylorus, and duodenum, to the gall bladder and the liver during the fasting stage and after a meal.

"*The Stomach* (*The Pyloric Orifice*).—Its position varies with the movements of the stomach. When the stomach is empty the pylorus is situated just to the right of the median line of the body, on a level with the upper border of the first lumbar vertebra. As the stomach becomes distended the pylorus moves to the right, and in a fully distended stomach may be situated two or three inches to the right of the median line.

"*Alterations in Position.*—When the stomach is distended, its surfaces, which are flattened when the organ is empty, become convex. The greater curvature is elevated and carried forward, so that the anterior surface is turned more or less upward and the posterior surface downward, and the stomach brought well against the anterior wall of the abdomen.

"When the stomach becomes distended the change in position of the pylorus is very considerable; it is shifted to the right, some two or three inches from the median line, and lies under cover of the liver, near the neck of the gall bladder.

"*The Small Intestine* (*The Duodenum*).—In the adult, the course of the duodenum is as follows: commencing at the pylorus, the direction of the first portion depends upon the amount of distention of the stomach and therefore upon the position of the pylorus. When the stomach is empty and the pylorus situated at the right of the upper border of the first lumbar vertebra, it is nearly horizontal and transverse, but when the stomach is distended, in consequence of the alteration of the position of the pylorus to the right, the proximal end of the duodenum also becomes altered in position, while the distal end remains fixed and the direction of this portion of the bowel is now anteroposterior. Whether directed transversely or anteroposteriorly, it reaches the under surface of the liver, where it takes a sharp curve and descends along the right side of the vertebral column, for a variable distance, generally to the body of the fourth lumbar vertebra.

"The first or superior portion is very variable in length, but is usually estimated as being about two inches. Beginning at the pylorus, it ends at the neck of the gall bladder. It is the most movable of the four portions. It is almost completely covered by peritoneum derived from the two layers of the lesser omentum, but a small part of its posterior surface near the neck of the gall bladder and the inferior vena cava is uncovered. It is in such close relation with the gall bladder that it is usually found to be stained by bile after death, especially on its anterior surface. It is in relation above and in front with the quadrate lobe of the liver and gall bladder; behind with the gastro-duodenal artery, the common bile duct, and the vena porta, and below with the head of the pancreas.

"*The Stomach.*—The pyloric end for about one inch from the pylorus remains narrow, but to the left of this it bulges forward, forming the antrum pylori, which is most distinct at the great curvature. By the increase of the organ in length the antrum is carried a considerable distance to the right beneath the liver—even farther than the pylorus itself—so that the terminal part of the stomach is bent backwards and to the left, in order to reach the pylorus, which latter very rarely passes more than one and one-half or two inches to the right of its normal position, namely, in the empty condition, within half an inch of the middle line.

"*The Duodenum.*—When the stomach is distended, the first inch of the duodenum—which

is movable on account of its peritoneal covering—is carried to the right with the pylorus, and thus brought into line with the second or terminal half, which is always directed backwards. Hence the whole of the first portion of the duodenum is directed backwards when the stomach is full."

THE CYSTIC DUCT AND THE HEISTERIAN VALVES

Stanley H. Mentzer states: "The cystic duct is not constant in shape in man. In a series of 612 cystic ducts examined at necropsy, only 19 were true S-shaped, 41 were single curves sharply flexed on themselves. In five, the duct was straight."

He quotes Jacobson and Geydesen as asserting that the gall bladder can be distended almost to the bursting point without forcing bile out of the cystic duct, whereas it can be easily emptied by slight longitudinal traction on the duct.

The valves of Heister are projections of mucous membrane into the lumen of the cystic duct. He found no uniformity in their arrangement. In most specimens the leaflets ran in a spiral clock-wise manner partially encircling the duct.

Our interpretation of the mechanical features entering into the evacuation of the gall bladder is as follows:

The peculiar attachment of the liver by its inner and posterior portion allows it to move upward and outward with a rotary motion. This permits accommodation of the abdominal contents to changes in weight or increases in abdominal pressure due to pregnancy, tumors, and to the empty and the filled stomach. The gall bladder, because of its attachment to the liver, undergoes a similar motion. This also accounts for its various locations in the abdomen in asthenic and hypersthenic individuals.

Our interpretation of the action of the cystic duct: It is a hollow fibro-muscular tube lined by a redundant mucous membrane connecting the common duct with a movable organ (the gall bladder attached to the liver). Like any mechanical attachment between movable parts, it must be able to handle the play between them. After a full meal, the gall bladder is pushed upward and outward from one to two inches by the full stomach and undergoes a certain amount of rotation because of its attachment to the liver. This straightens the cystic duct and allows it to readily empty into the common duct, as stated by Jacobson and Geydesen. We ourselves have repeatedly demonstrated in rabbits and guinea pigs that moderate traction on the gall bladder will straighten the cystic duct, and readily empty the gall bladder. When the stomach is empty, the muscular portion of the duct assumes some modification of the S-shape by its own contractability, and the redundant mucous membrane, if rotated, would assume a spiral shape.

This straightening of the cystic duct, caused and accompanied by the pressure of the filled stomach upon the gall bladder and liver, would account for the first period of Boyden, the "initial response" (two minutes) and also for McMaster and Elman's results, the *immediate rising* of bile in the tube attached to the gall bladder, upon taking food (in five to ten seconds). It also explains how the straightening of the cystic duct after eating, allows some gall bladders to fill and empty normally after eating, when they would not fill before eating.

The uppermost portion of the duodenal cap is attached to the neck of the gall bladder and the liver. Most of the antrum and cap are freely movable and undergo a similar change in location because of changes in habitus, etc. The type of peristalsis of the antrum, which has been previously described, carries it up against the gall bladder, pressing it against the liver, and exerting additional pressure sufficient to overcome the sphincter, thus emptying it periodically by spurts. At the same time the passage of food into the duodenum produces distention of the cap, resulting in increased peristalsis and lowering of the tone of the sphincter, as we have seen above. The pressure of the filled stomach, and peristalsis of the antrum and cap exerting pressure on the gall bladder, explain the changes

in shape the gall bladder undergoes after eating and during its emptying. This explanation makes unnecessary the assumption of a dual nervous control, one impulse causing the gall bladder to contract, and a synchronous impulse causing the sphincter to relax. Gastro-duodenal peristalsis and emptying of the gall bladder occur when all nerves are severed.

Fig. 21.

Fig. 22.

Fig. 21. Both the gall bladder and stomach are visualized. The antrum and cap do not contact the gall bladder in such a manner as to exert pressure on the gall bladder against the liver. This gall bladder did not empty in 24 hours.

Fig. 22. A gall bladder visualized intravenously. Stomach visualized. Duodenal ulcer. The contact of the antrum and cap with the gall bladder is good; however, in none of the series was there active peristalsis of the antrum. There was a heavy residue in the gall bladder at 24 hours. This patient gave a clearcut ulcer history.

We believe that the mechanical factors enumerated above can explain the emptying of the normal gall bladder in the time and manner in which it is known to empty. Other factors which increase or decrease the secretion of bile, or increase or decrease the muscle tone of the gall bladder or the tone of the sphincter, play a minor rôle in emptying the gall bladder. When the normal processes are interfered with by disease or operation, these minor factors probably are an aid. For instance, when the gall bladder is removed, secretory pressure overcomes the sphincter of Oddi. In gastro-enterostomies, it is quite possible that a similar mechanism eventually comes into play. Apparently duodenal peristalsis is normally initiated by distention of the cap, as gastric waves do not cross the pylorus. If they are not normally started in the cap because of the pyloric stenosis, they must be started in the jejunum at the artificial opening by distention of the food. This might result in a retrograde peristalsis of the cap producing a lowering of the tone of the sphincter, or the inactivity of the duodenal cap, because of the closed pylorus might result in a lack of tone of the sphincter. It is extremely doubtful if the gall bladder would remain normal over a long period of time in gastro-enterostomy cases. Kalk and Nissen report 12 cases (12 tests made): six emptied completely after the high fat meal, five showed an emptying and a shrinkage of the gall bladder to one-fourth its original size, one showed no emptying—a rather high percentage of delay in emptying.

Our greatest objection to the hormone

("cholecystokinin" of Ivy) theory of evacuation of the gall bladder is the time element. McMaster and Elman, and Boyden have clearly demonstrated a rise in gall-bladder pressure and a marked emptying of the gall bladder in from 15 seconds to one minute after taking food. It does not seem possible for food to be absorbed from the duodenum, enter the lacteals, pass through the thoracic duct, enter the circulation, and return to the gall bladder in sufficient quantities to produce a marked contraction in this time, nor would it account for the peculiar manner of delivery of bile described by the above authors.

A successful theory must explain all the known facts. We have reviewed the known facts in gall-bladder evacuation, and have shown how they can all be explained on a mechanical basis.

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THE ROENTGENOLOGIC ASPECTS OF OSTEOMYELITIS OF THE SKULL

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AMONG the numerous diseases of the skull which may engage the attention of the roentgenologist, osteomyelitis is not the least important. In other portions of the skeleton, the condition is foremost among the affections which must be considered when pathologic changes are presented upon the roentgenogram. In the skull, however, it takes a subordinate place, due to the fact that it is not of common occurrence and that it nearly always presents itself as a complication of some primary focus of infection elsewhere. For these reasons, the condition has not attracted or received much attention in roentgenologic literature. Nevertheless, because of its close etiologic association with the cranial sinuses, including the mastoids, the gravity of the disease when well established, and the fact that the roentgenogram affords a graphic although somewhat belated record of the course of events, the subject of osteomyelitis of the skull should engage the serious consideration of the general roentgenologist.

In considering osteomyelitis of the skull, the conventional restrictions of the term, as used elsewhere in the body, to the pyogenic and non-specific infections are accepted, thus excluding syphilitic, tuberculous, actinomycotic, and the rarer forms of osteomyelitis. Furthermore, as is generally understood, the skull in this presentation will be confined to the cranium, more particularly the calvarium, since it is in this location that osteomyelitis is most commonly encountered and most readily demonstrated roentgenologically. As a diagnostic problem, the condition does not give much concern, since its secondary nature and close association with the primary infection renders its roentgenologic recognition comparatively easy. However, since it may occasionally appear spontaneously and apparently idiopathically, the disease must be given due consideration in the differential diagnosis of lesions involving the skull.

The literature clearly reflects the etiology of the condition since most of the contributions on the subject have appeared in journals devoted to rhinology and otology, thus indicating that the disease most frequently arises from the paranasal sinuses and mastoids, particularly the former. For the most part, only casual references are made to the roentgenologic aspects, and for this reason it would seem desirable to emphasize this phase of osteomyelitis of the skull, and thus bring to the attention of roentgenologists a condition with which he must of necessity be familiar for the proper interpretation of roentgenograms of the head. To fully appreciate the changes to be seen upon the roentgenogram in osteomyelitis of the skull, one must have some knowledge of its etiology, pathology, and clinical manifestations, and for this reason a brief résumé of the modern concepts of the condition is presented.

ETIOLOGY

The etiology of osteomyelitis of the skull permits sub-division, and facilitates discussion of the subject under four distinct headings: (1) paranasal sinus disease; (2) mastoid disease; (3) metastatic or hematogenous spread; (4) skull trauma. By far the most common cause is extension from infection in the paranasal sinuses. The other three etiologic factors are less frequently encountered. Each, however, presents certain distinctive features which make it necessary to consider them individually.

Osteomyelitis Due to Paranasal Sinus Dis-

ease.—The fact that osteomyelitis of the skull is the least frequent of all complications of paranasal sinus disease is substantiated by Bourger (1). He analyzed a series of 534 complications occurring during the course of sinusitis and found but two instances of osteomyelitis. In the same series, brain abscess developed in 176 patients, purulent meningitis in 170, cavernous sinus thrombosis in 61, and extra-dural abscess in 54. While we cannot quote statistics, it is our impression that Bourger reported a particularly fortunate group, and that Munro (2) was closer to the actual facts when he stated that osteomyelitis accounted for about 3 per cent of the complications of sinus disease.

Infections within the frontal sinuses account for most of the cases developing calvarial osteomyelitis as the result of paranasal sinus disease. In a series of 48 patients with osteomyelitis secondary to sinus infection reported by McKenzie (3), the frontal sinuses were to blame in 45 patients, whereas the maxillary and ethmoidal sinuses were at fault in the remaining three cases. The majority of evidence also indicates that the incidence of osteomyelitis is about the same in chronic sinus disease as in the acute infections.

Much has been written concerning the relationship between operations upon infected sinuses and the development of osteomyelitis. Undoubtedly the trauma of radical sinus surgery may, as Furstenburg (4 and 5) and Wilensky (6 and 7) believe, account for the onset of the disease in some patients. Perhaps injury to the periosteum may be of prime importance. If these facts are true, Dixon's (8) plea for simple incision and drainage in patients with sinus disease is not without merit. It seems to us, however, that operative procedures have little bearing upon the development of osteomyelitis, because of the frequency with which it develops in patients not operated upon, and the number of instances in which the disease is first identified at the time of operation. It seems more than likely that, in most patients developing osteomyelitis after operation, the disease was present, although not recognized, prior to surgical intervention.

From the maxillary sinus, extension occurs, as a rule, to the frontal bone, as in the case reported by Hanson (9). The manner of spread and the type of calvarial involvement is exactly the same as in osteomyelitis from the frontal sinus. The ethmoid and sphenoid sinuses have been reported as the etiologic site in a few cases, the infection usually spreading into the base of the skull.

Osteomyelitis Due to Mastoid Disease.—Osteomyelitis of the skull following otitic infection occurs less frequently than in the case of sinus disease. Perhaps the anatomy of the mastoid, and the character of the operations employed in removing all of the pneumatized bone, have some bearing upon its infrequency. As Wilensky (10) has pointed out, the dense bone around the infected mastoid does not invite infection as readily as diploic bone. The type and manner of spread are usually the same as those found in sinus disease.

Osteomyelitis Due to Metastatic Infection.—When one considers the extreme vascularity of the diploe, it is rather remarkable that patients with transient periods of blood stream infection do not develop osteomyelitis of the skull more frequently. Fortunately, the tissues of the calvarium must be devitalized before bacteria circulating in the blood can start an infectious process. Injuries to the head sometimes result in osteomyelitis of the skull even though the scalp is not penetrated by the trauma. Possibly bacteria, normally circulating in the blood stream, are responsible for such infections. Sometimes an infected tooth (Blair, 11, and Hastings, 12), or a carbuncle (Kuster, 13), has been the primary site in patients developing metastatic osteomyelitis without injury to the head. However, there will always remain the unexplained case in which no etiologic factors can be found, as in the patient reported by Meyers (14).

Osteomyelitis due to hematogenous metastasis from osteomyelitis in some other portion of the body, as in the long bones, is much less common than any mode of exten-

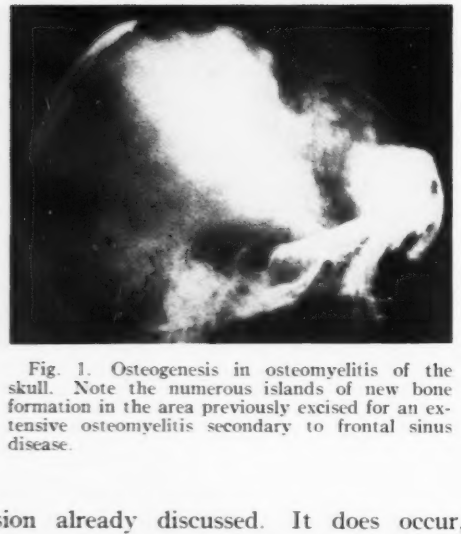

Fig. 1. Osteogenesis in osteomyelitis of the skull. Note the numerous islands of new bone formation in the area previously excised for an extensive osteomyelitis secondary to frontal sinus disease.

sion already discussed. It does occur, however, and it must always be considered when a patient with osteomyelitis elsewhere develops evidence of a localized inflammatory process in the scalp.

Osteomyelitis Due to Trauma.—Under this heading must be considered those cases developing as the result of surgical procedures and head injuries. The thickness of the scalp and the density of the outer table of the skull apparently prevent ingress of infection, as Adelstein and Courville (15) have indicated. This may account for the apparent inherent resistive powers of the skull to infection, since osteomyelitis due to trauma is much more frequent in the long bones. Traumatic osteomyelitis of the skull is usually the result of a penetrating wound with bone damage, or an abrasion of the skull with multiple minute particles of dirt ground into the bone. In some instances, osteomyelitis has followed injury without damage to the scalp. In such cases the infection has been thought to have occurred from the blood stream or from a pre-existing infection in the hair follicles. As a rule, traumatic osteomyelitis occurs in the temporal and parietal bones, whereas osteomyelitis due to sinus disease almost invariably involves the frontal bone. Osteomyelitis following neurosurgical procedures is uncommon. In these cases the disease is usually the result of faulty local asepsis and less commonly to infection from the blood stream.

Age and Sex.—Most observers are of the opinion that osteomyelitis of the skull occurs more frequently in women than in men. This is probably due to the increased vascularity of the skull in females as compared to males, first demonstrated by Berchet. There has been noted also a predilection for the disease to occur in young patients, between the ages of fifteen and thirty. Bulson (16) and others have attributed this age preference to the increased vascularity necessary for normal growth of the young skull. Our experience substantiates these views, since most of our cases have occurred in females and in the age limits indicated.

PATHOLOGY

Munro (2) defined osteomyelitis of the head as "a rarefying destructive osteitis, involving the diploic channels of the calvarium, resulting from a spread of an infective thrombotic process."

By far the most common infective organism in osteomyelitis of the skull is the staphylococcus. It is much more commonly found than the hemolytic streptococcus, although, according to Dabney (17), this latter organism is being encountered more frequently since the influenza epidemic in 1918. In the opinion of some, osteomyelitis due to the streptococcus is almost invariably fatal, whereas Woodward (18) has stated that staphylococcic calvarial infections have a much more favorable prognosis. Pneumococci have been isolated from some lesions, and in one patient, reported by Munro (2), actinomycosis was identified.

In 1913, McKenzie (3) described the pathogenesis of osteomyelitis of the skull, and was one of the first to express the opinion that it is frequently associated with frontal sinus disease. He believed that the infection extended directly through the bony wall of the sinus into the calvarium in the vast majority of cases, while in some instances the infection involved the small efferent veins of the membrane lining the

sinus and was thus carried directly into the surrounding bone. While it is true that great differences exist in the thickness of the bone and in the development of the diploe surrounding the frontal sinuses, as recently described and emphasized by Furstenburg, nevertheless, along with McKenzie, we are not impressed by its importance in the development of osteomyelitis of the skull. We believe that in most instances the development of osteomyelitis depends upon the relationship which exists between the virulence of the infecting organism and the inherent protective mechanisms of the host.

Inadequate drainage in sinus disease may play an important part in the development of osteomyelitis. It may be that "the long continued contact of infection in an undrained cavity," spoken of by Dabney (17), or the "occlusion of pus under pressure with interference of blood supply," referred to by Woodward (18), are vital factors in its development. Least important of these etiologic possibilities seems to be its dependency upon the anomalous development of the frontal sinuses, as indicated by Luc (19).

Whatever its mode of onset, the infection spreads by retrograde thrombosis in the diploe of the calvarium, after having entered the small efferent vessels in the mucous membrane lining the sinus. Once having entered the diploe, it may spread without difficulty to all parts of the calvarium because of the free anastomosis and multiplicity of its blood channels. During the first few days the bone seems practically normal except for some hyperemia of the area. The hyperemic stage soon becomes associated with small miliary droplets of pus, which, within a week to ten days, increase to such an extent that the involved portion of bone becomes bathed in copious quantities of pus. The infection then spreads in a serpentine manner in all directions. The purulent material may burrow through the outer table of the skull and produce a localized abscess in the scalp. The infection may penetrate into the cranial cavity and result in any one of numerous

Fig. 2. Acute localized osteomyelitis of the right frontal sinus. Note the ragged, rarefied, and indistinct outline as compared to the appearance of the left sinus.

intracranial complications. Fortunately, the spread is almost invariably toward the vertex, since involvement of the base of the skull is usually fatal.

There has been some discussion as to whether the inner or outer table of the vault is first involved in osteomyelitis. According to Furstenburg, a cushion of exudate develops upon the dura very early in the disease which separates it from the inner table of the skull. Since it is believed that the cranial bones receive most of their blood supply from the dura, such a collection interferes with the nutrition to the overlying bone, thus resulting in a destruction of the inner table and favoring a spread of the infection by retrograde thrombosis. Wilensky (20), however, feels that the outer table gives way first, whereas Bulson (16) believes that the pus develops on both sides of the infected bone at the same time.

It has been stated that the sutures show a tendency to limit the spread of osteomyelitis of the skull in young persons for a short period of time. This retardation is probably due to the fact that the sutures in the young are not yet united and thus

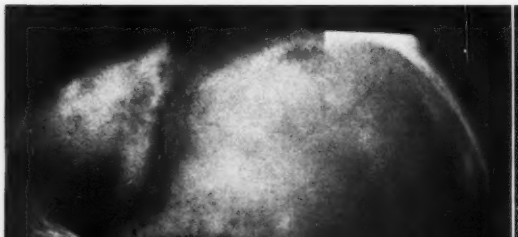

Fig. 3. A spreading osteomyelitis of the squamous portion of the temporal bone following a chronic mastoiditis. Note the sieve-like rarefaction spreading in all directions for a considerable distance beyond the primary focus.

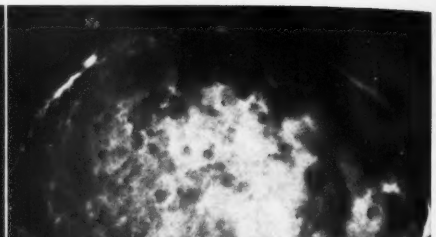

Fig. 4. Same case as in Figure 3, six months later. Almost complete involvement of the entire calvarium. Numerous operations had been performed in an attempt to check the spread of the disease.

there is a break in the direct continuity of the diploe. The connective tissue and compact bone which constitute the sutures in the young skull act as a temporary barrier to the spread of infection. In adults, this zone of differentiation from the surrounding diploe is no longer present, thereby favoring the spread of the infection by direct continuity of skull structures.

Osteomyelitis of otitic origin may spread into the calvarium, involving first the squamous portion of the temporal bone (Fig. 3), the occipital, parietal, and frontal bones being involved later. The disease may extend from the mastoid along the petrous pyramid with resulting infection of this structure. The nature of the pathology in osteomyelitis of the petrous pyramid or so-called petrositis, a term first used by Profant (21), is dependent upon whether or not the petrosa is fully pneumatized. In the absence of complete pneumatization, the infection constitutes a true osteomyelitis, as occurs in diploic bone in any other portion of the skull. This has been fully described by Eagleton (22), who states that infection may reach the petrous apex by way of: (*a*) a retrograde thrombophlebitis of the perilabyrinthine veins; (*b*) through the labyrinth, or (*c*) by way of the pneumatic cells which surround the labyrinth. With pneumatization of the petrosa, the infection spreads along the mucous membrane lining the cell walls, and is accompanied by a secondary osteomyelitis of the bone trabeculations exactly as occurs in an ordinary mastoiditis. However, because of the thinness of the osseous structures in the petrous apex, the infection readily spreads to the adjacent meninges, frequently giving rise to a fatal meningitis. This is the condition to which attention has recently been called by Taylor (23), Kopetsky (24 and 25), Geyman and Clark (26), and others.

Traumatic osteomyelitis of the skull has been thoroughly described by Adelstein and Courville (15), and we shall take the liberty of quoting freely from their excellent article. According to these authors, traumatic osteomyelitis may occur as one of three varieties. The first is characterized by a purely local skull defect which is surrounded by sclerotic bone. This sclerosis has been interpreted as the result of the inherent protective mechanism of the cranial bones to an avirulent type of infection. The second variety is also a localized type of bone lesion which, however, lacks the osteosclerosis just described.

It has been attributed to the type of trauma in which multiple small particles of infected material are ground into the outer layer of the skull. Numerous small purulent foci form about each particle of dirt. These foci soon enlarge and coalesce to form one large single defect. The disease usually remains localized in the outer table of the calvarium but in some instances penetration into the diploe occurs. The third, or spreading type of osteomyelitis, resembles that seen in association with sinus disease. Its manner of spread and clinical manifestations make it indistinguishable from the picture usually seen in sinus or mastoid extensions.

The fate of osteomyelitis in a bone fragment, due to a compound fracture or in those rare instances in which osteomyelitis develops in a bone fragment the result of hematogenous metastasis, as reported by Flemming (27), merits separate discussion. It is very interesting to note that there is usually no spread of the infection beyond the confines of the fracture, if healing of the fracture has started prior to the onset of the osteomyelitis. This limitation is probably due to the fact that the granulation tissue found along the healing margins of a fracture sets up a barrier to the spread of the infection in much the same manner as was discussed with reference to the protective value of the suture lines in young skulls. If, however, infection takes place before the reparative processes have had a chance to develop, the spreading type of osteomyelitis may readily follow the injury. Osteomyelitis, resulting from neurosurgical operations upon the head may disseminate in much the same fashion as described under spreading osteomyelitis. Fortunately, the disease is usually limited by the borders of the craniotomy, if the disease involves the bone flap only.

Metastatic osteomyelitis from foci of infection elsewhere in the body is rare. The nature of its calvarial spread is somewhat different, dependent upon whether the infective embolus lodges in the arterial or the venous system. In the former, the infection remains localized, whereas the venous involvement more frequently produces thrombophlebitis and retrograde extension with a more diffuse type of osteomyelitis. One must not forget that metastasis from osteomyelitis of the skull to other parts of the body may occur, as reported by Lexer (28). His patient with calvarial osteomyelitis developed an infection in the os calcis during the course of his illness.

CLINICAL MANIFESTATIONS

The marked toxicity, pain, and fever usually found in acute osteomyelitis of the long bones of the body are not as prominent in osteomyelitis of the skull. Indeed, in some instances the calvarium may be entirely destroyed with few systemic signs to indicate the severity of the disease. Most patients have marked malaise, frequently associated with either a localized or diffuse headache. Fever may or may not be present, though there are some patients in whom the disease is ushered in by a severe chill, rigor, and a high temperature. Blood culture taken during the height of the symptoms may or may not be positive. When a positive blood culture is obtained, the usual clinical manifestations of septicemia prevail. In the more severe infections, euphoria and complete loss of consciousness have also been described. One of the most common associated findings in this disease is a marked hypochromic anemia, which must be adequately combated if a favorable outcome is to be expected.

When the suppurative process extends into the cranial cavity, any one of several complications may arise. An extra-dural abscess may form, with resulting evidences of increased intracranial pressure. In some patients, purulent meningitis or thrombosis of one or more of the large venous sinuses may develop. Sudden death may result from any of these complications.

With perforation of the suppurative process through the outer layer of the skull, an entirely different group of signs and symptoms develop. Perforation through the anterior wall of the frontal sinus may result in narrowing of the palpebral fissure

due to the reactionary edema. If the extension is through the floor of the sinus, one usually can feel the lesion presenting in the roof of the orbit. The orbital tissues remain unaffected until the periosteum is broken through, after which they become edematous and swollen. Ethmoidal disease may perforate into the orbit, nasal cavity, or extend up into the crista galli and involve the cribriform plate. Sphenoidal infections sometimes burrow through the base of the skull and present in the neck as a retropharyngeal cellulitis.

Osteomyelitis of the outer table differs in its symptomatology from involvement of the inner table of the calvarium. Of course, there are many patients in whom both tables are affected, and because of this there is certain to be considerable overlapping of symptoms. As a rule, however, infections of the outer table are associated with edema and tenderness soon after the onset of the disease, and according to Wilensky, this edema is much more widespread than the actual area of bone involvement. This external edema and swelling overlying an area of osteomyelitis of the skull was first described by Pott (29), and has since been known as Pott's Puffy Tumor. Osteomyelitis of the inner table is usually not associated with edema and tenderness recognized externally. The only consistent symptom has been deep seated intractable pain localized to the area of bone involvement.

In spite of all that has been written and described in an effort to recognize the disease early, the clinical diagnosis still remains uncertain and difficult in the first stages of the disease.

OSTEOGENESIS IN OSTEOMYELITIS OF THE SKULL

In most of the cases reported in the literature, regeneration of the involved bone took place in those patients recovering from the disease. Furstenburg (30) and Wilensky (20) have contributed much toward our knowledge of osteogenesis in this disease. In the stage of repair, a rapid multiplication of the connective tissue elements takes place at the site of the infection. After a short period of time some of the connective tissue cells become differentiated and assume the characteristics and function of mature osteoblasts. As a result, an interlacing network of uncalcified osteoid tissue is formed, and after calcium has permeated this tissue bone trabeculæ become evident. This series of events was described by Furstenburg, who has demonstrated bone regeneration in the granulations arising from the dura and affected periosteum. Mosher and Judd (31) recently demonstrated the same process in their excellent contribution on the subject. These observations at first seem at variance with the experience of neurosurgeons, who seldom see regeneration of bone after craniectomy. There is good experimental evidence to show that unless "bone dust" or "bone flakes" are allowed to remain at the operative site bone regeneration will not take place. Infection probably also plays a part in the stimulation of the factors responsible for bone regeneration, and no doubt explains the lack of regeneration in sterile craniectomies. According to Furstenburg, regeneration starts in the center of the cranial defect and gradually spreads toward the periphery but seldom joins the bone at the edge of the defect. Sometimes this process may start in multiple small foci, which in appearance closely resemble the areas of epithelization seen in the skin after multiple pinch grafts (Fig. 1).

ROENTGENOLOGIC CONSIDERATIONS

From the foregoing considerations it is quite obvious that the anatomy of the bones of the skull is of considerable importance as regards involvement by osteomyelitis. The various parts of the calvarial bones essential to the pathogenesis of osteomyelitis are well depicted in roentgenograms of the head. The inner and outer tables, the diploe, and the vascular channels are clearly shown. Roentgenography of the skull enables one to appreciate the great variation that exists in these structures in normal individuals. There is considerable variation in the thickness of

the bones of the vault. In many instances the inner and outer tables consisting of dense cortical bone, appear to be in contact with each other with a minimum amount of diploe interposed. In other individuals, there is a thick layer of diploe, which in the lateral view appears as a coarse stippling of the bone. There is no definite relationship between the presence of this stippling and the thickness of the diploe, since a very thick inner and outer table and a fine diploic mesh may completely obliterate the stippling produced by the diploe even though the bones may be of unusual thickness. Considerable variation may also be found in the diploic channels or veins of Berchet, as depicted roentgenologically. There may be a complete absence of such channels or they may be numerous and of variable size and position. They appear most commonly as a stellate figure in the region of the parietal eminence. Since these channels are not always visible, the roentgenogram does not give a true picture of the vascularity of the bones of the vault. This is further indicated by the infrequency of vascular channels in the roentgenograms of children, when as a matter of fact there is a greater vascularity as compared to adults. Of considerable practical importance are the small areas of translucency frequently observed in various portions of the skull, especially along the course of the diploic channels. These are due to normal vascular dilatations and are frequently referred to as venous lakes. They deserve special consideration since they may simulate a variety of pathologic lesions encountered in the skull including osteomyelitis. One cannot account for the occurrence of osteomyelitis on the basis of the bone structure as revealed by the roentgen ray, which leads one to accept the conclusion that the important factors in the development of this condition are the virulence of the infecting organism and the resistance of the host.

Osteomyelitis of the skull is regarded pathologically as a process similar to osteomyelitis in other bones of the skeleton. The same anatomic structures exist in the skull as are found in the long bones, the inner and outer tables corresponding to the cortex, while the diploe constitutes the marrow of the calvarial bones. The diploic veins are analogous to the venous channels, which permeate the marrow cavity elsewhere in the osseous system. Despite this similarity there are certain differences which exist, and these are reflected roentgenologically in the dissimilarity of osteomyelitis of the skull as compared to the same condition found in other parts of the skeleton.

As observed roentgenologically, osteomyelitis of the skull may be considered under two distinct headings, (1) the localized and (2) the spreading type of infection. These present distinctly different appearances. The differentiation is of the utmost importance from a clinical point of view, since the localized form does not usually endanger life whereas the spreading type carries with it a high mortality.

LOCALIZED OSTEOMYELITIS OF THE SKULL

The roentgen manifestations of the localized form can be considered best upon the basis of its etiology. Since osteomyelitis is most commonly found in association with paranasal sinus disease, this should receive first consideration. Roentgenologists are not prone to think of this condition in the routine interpretation of roentgenograms of the paranasal sinuses. Careful attention should be given to this possible complication since its detection is of such clinical importance. The rhinologist should be forewarned of the presence of bone infection so that therapeutic measures may be taken to prevent the tragic sequelæ of a spreading osteomyelitis.

As already stated, the frontal sinuses are the ones which most frequently give rise to this condition. Evidence of bone involvement is a common observation in chronic infections of these sinuses. Pfahler (32), and others, have called attention to the increased density of the bone surrounding the chronically infected frontal sinus. This osteosclerosis is regarded as the end-result of a low grade non-virulent osteitis.

the resistance of the host having been sufficient to prevent the lesion from spreading. The thinness of the cortex in this region and the intimate contact with the underlying diploe raises the question as to whether or not such an osteitis is not in reality an osteomyelitis. Clinically and roentgenologically, the distinction cannot be made. The point, therefore, is of academic interest only. Of practical significance is the fact that the obvious and more serious form of osteomyelitis has its inception in just such a process. The acute stage of this localized osteitis or osteomyelitis is seldom recognized since the roentgen manifestations are not marked. Accompanying an acute frontal sinusitis, there may be noted at times a slight demineralization of the bone immediately surrounding the sinus. This may be the result of a disturbance in blood supply due to thrombosis of the vessels which penetrate the bone from the infected sinus, or may indicate the onset of an acute osteomyelitis. The differentiation roentgenologically is difficult to make. The clinical manifestations are of little aid since in this early stage one cannot separate the symptoms due to the sinusitis from those due to bone infection. The osseous changes may comprise the entire or only a small portion of the periphery of the sinus. Such a localized osteomyelitis is of rather frequent occurrence. The fact that in the vast majority of instances the condition subsides without serious consequences speaks well for the inherent resistance to infection of the bones of the calvarium. Unfortuately, one must wait until a somewhat greater area of involvement is seen upon the roentgenogram to be certain of an existing osteomyelitis. At this time, there are also usually some external manifestations of the condition. Upon the roentgenogram, the periphery of the sinus becomes ragged, and the rarefaction extends for a variable distance into the surrounding bone (Fig. 2). When the disease is unilateral, as occurs in the vast majority of instances, a comparison of the affected with the uninvolved sinus tends to accentuate the changes due to the osteomyelitis and renders recognition of the condition less difficult. Under favorable circumstances, the disease will remain localized and after a time will subside, the reparative process being indicated by an increased density of the bone, the extent depending upon the area of involvement.

The reactive bone changes in osteomyelitis of the frontal sinus may become quite marked. Skillern (33) has recently directed our attention to a complete obliteration of the frontal sinus by new bone formation under such conditions. In these patients, the frontal sinus upon the roentgenogram may be extremely faint or its outline may be entirely lacking, depending upon the degree of obliteration. Such cases are frequently reported by the roentgenologist as showing a lack of development of one of the frontal sinuses. Obliterative osteogenesis must be thought of when confronted by an apparent absence of one of the frontal sinuses in an adult. When the roentgenogram shows a large unilateral frontal cell which ends abruptly in the mid-line, one must suspect an obliterative osteitis in the opposite sinus. The condition is apparently not uncommon, as we have observed it a number of times during the past year. A detailed history from the patient may or may not reveal evidence of previous frontal sinus disease. In the lateral roentgenogram, one may at times detect a slit-like remnant of the original frontal sinus, or exposures made at angles somewhat different from the routine technic, or made with the Potter-Bucky diaphragm may serve to visualize the faint outline of the sinus. We have found the Waters position, as used for the maxillary sinuses, particularly valuable for this purpose.

The position of the frontal sinuses lends itself to the ready recognition of an osteomyelitis of the surrounding bone. That similar infections occur in association with the ethmoid, sphenoid, and maxillary sinuses is evident from the reported cases of spreading osteomyelitis from these sinuses. The local manifestations, however, are

difficult to detect both roentgenologically and clinically, and no doubt usually go unrecognized.

A localized osteitis or osteomyelitis of otitic origin is as common as that occurring in frontal sinus disease. Here again the local resistance is such as to prevent the infection from gaining headway in the surrounding bone. The osteosclerosis so commonly observed in the mastoid and around the middle ear denotes the frequency of this condition. The chronic otitic discharge found in association with a diploic type of mastoid or persisting after a radical mastoidectomy is usually the result of a localized osteomyelitis, although it is not always recognized as such.

The outstanding example of a localized osteomyelitis of otitic origin is the so-called petrositis. There are recognized two distinct varieties of this condition, one in which the infection spreads from the mastoid to the petrous apex by means of a retrograde thrombophlebitis, and the other in which the infection spreads by way of pneumatic cells. Obviously the latter can occur only in a pneumatized petrous pyramid. Both may give rise to suppuration of the petrous apex, a condition which is exceedingly serious, frequently resulting in a fatal intracranial infection. Taylor (23) has advocated the base view as the best means of demonstrating a petrositis roentgenologically. This enables one to compare the infected with the uninvolved side. As emphasized by Taylor, the base view should be a part of the routine mastoid examination. This plate serves for purposes of comparison with subsequent roentgenograms, should petrositis develop or be suspected. In most instances of acute mastoiditis, there will be noted a definite increased density of the petrous pyramid on the involved side, as seen in the base view. This may be due to an acute hyperemia of the bone or swelling of the overlying soft parts. This appearance is usually of little consequence. In the presence of suppuration of the petrous apex, there is a loss of bone detail and the area becomes less dense and more homogeneous in appearance than the opposite side. While our experience with petrositis is somewhat limited, we have found the anteroposterior projection of the mastoid most helpful and use it routinely in addition to the base view. In several instances, a break in continuity of the petrous ridge near the base of the petrous pyramid, as seen in the anteroposterior projection, has enabled us to detect a petrositis which has subsequently been confirmed at autopsy. In these cases, the petrous pyramids were not pneumatized, which probably accounts for the fact that the osteomyelitis spread toward the petrous ridge rather than toward the apex.

The metastatic or hematogenous osteomyelitis of the skull may be of either the localized or spreading variety. The clinical symptoms will usually direct attention to the area of the skull involved. An acute inflammatory process of the scalp, when associated with an osteomyelitis in some other portion of the body, greatly lessens the diagnostic difficulties. Occasionally such a lesion occurs from some less obvious focus of infection such as an abscessed tooth or infected tonsils. Nevertheless, the local signs and symptoms of osteomyelitis of the skull are usually such as to make this condition a distinct possibility in the differential diagnosis. Of particular interest is the spontaneous area of osteomyelitis occurring secondary to and at some distance from a focus of infection elsewhere in the head, usually a frontal sinus. Unless the primary infection is a particularly severe one, the relationship to the metastatic lesion may not be suspected. In such cases, the new area of involvement is usually the result of a thrombophlebitis of the diploic channels leading from the affected sinus, and in reality constitutes a spreading rather than a localized form of osteomyelitis. Such infections are likely to be particularly severe.

As occurs elsewhere in the skeleton, the roentgen manifestations of osteomyelitis of the skull are late in making their appearance. Usually the characteristic changes are not apparent from a week to ten days following the onset of the bone infection.

A negative roentgenogram within this time does not therefore exclude an osteomyelitis. The condition may start as a small area of rarefaction which may be difficult or impossible to distinguish from a venous lake. A knowledge of the history and of the location of the external manifestations is essential if one is not to overlook or fail to appreciate the significance of such a small radiolucent area. At other times, the earliest evidence may be a small area of slight demineralization which blends imperceptibly with the surrounding bone. The radiologist must have osteomyelitis in mind if he is to detect and recognize such a slight alteration in bone density. But it is at this stage that recognition is of most importance since the diagnosis from the clinical point of view is usually not definite. Later, when the small rarefaction has increased considerably in size or the slightly demineralized area has assumed a moth-eaten appearance (Fig. 3), the diagnosis is usually no longer in doubt and the roentgen examination serves merely to graphically record the severity and extent of the lesion. In the purely localized form of metastatic osteomyelitis, the infection shows little tendency to spread beyond the confines of the primary involvement. Complete absorption of bone may or may not occur. Usually, various sized, irregular, and dense sequestræ stud the affected area which merges gradually with the surrounding normal bone.

Healing occurs by bone regeneration which fills in the defects resulting from osseous destruction. The area takes on an increased density which is quite irregular in appearance. If the infected bone has been removed surgically a permanent cranial defect will remain unless the area of involvement is very small or unless bone chips are left in the area to initiate osteoblastic activity. The edges of such defects are usually smooth and rounded, presenting the appearance of normal bone. Increased density of the edge of the cranial defect does not occur unless such edges have been the site of an osteomyelitis.

Under traumatic osteomyelitis must be considered those infections occurring incident to injuries of the head and those following various surgical procedures upon the calvarium. These are not common causes of osteomyelitis of the skull, since injuries severe enough to damage the skull usually receive prompt surgical treatment in which prophylactic measures against infection are used and because cranial surgery is performed under aseptic conditions. Nevertheless, osseous infections do occasionally occur and these are usually of the localized variety. Spreading osteomyelitis seldom results from a fracture of the skull, for the same reason that bone infection complicating fractures of the long bones usually remains localized. The fracture serves to decompress the bone, and the infection, taking the path of least resistance, escapes to the soft tissues.

In traumatic osteomyelitis, the bone changes present the same appearance roentgenologically as has been previously described. The edges of the fracture or craniotomy wound become slightly rarefied, irregular, and less distinct. At this stage, it may be difficult or impossible to differentiate the appearance of an early osteomyelitis from the localized demineralization of bone which normally occurs under such conditions. Careful correlation with the patient's clinical manifestations is essential for proper interpretation. As the infection progresses, small pin point foci of rarefaction extend for a variable distance into the surrounding bone. Opportunity for the wound discharges to escape will usually prevent the infection from spreading. With subsidence of the infection, the areas of involvement increase in density and may stand out in sharp contrast to the neighboring bone. Very little if any osseous regeneration occurs beyond the edges of a craniectomy opening. Fracture lines and osteoplastic flaps ossify, as normally occurs in the absence of infection.

SPREADING OSTEOMYELITIS OF THE SKULL

The spreading type of osteomyelitis is the same pathologically and roentgenologically, regardless of whether the infection proceeds from a focus in the paranasal si-

Fig. 5. Same case as in Figure 4, six months later. The infection has practically subsided. There is now extensive new bone formation throughout the skull, producing a marked irregularity in contour and an increase in density. (This case is to be reported by Dr. O. C. Hirst.)

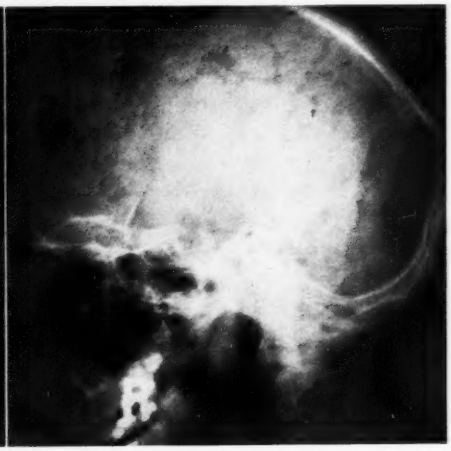

Fig. 6. Spreading osteomyelitis along the diploic channels. Extensive osteomyelitis of the frontal bone following acute frontal sinus disease. Numerous small areas of rarefaction are clearly shown along the diploic channels extending as far back as the occipital bone. Complete recovery under conservative treatment.

nuses or mastoid, or whether it is metastatic or traumatic in origin. It does, however, present a distinctly different picture from that seen in the localized form. Dissemination may occur in one of two ways, either by continuity or by way of the diploic channels. When the infection spreads by continuity, the involved area will be found studded by minute foci of rarefaction, the appearance being quite characteristic. The rate of progression of this type of infection is not very rapid. Again it must be remembered that the infection has advanced for some distance beyond the visible point of involvement as detected upon the roentgenogram. As the condition progresses, the small points of rarefaction enlarge and coalesce, giving the involved area a characteristic moth-eaten appearance. The area, deprived of its blood supply, becomes studded with small irregular and rather dense sequestræ. Always in advance of the spreading lesion is to be found the sieve-like zone of rarefaction (Fig. 3). Such a lesion will usually continue to spread until surgical drainage is established. This is not always successful in checking the condition, and the lesion may continue to spread until the entire calvarium is involved (Fig. 4), or death ensues as a result of toxemia, meningeal or cerebral complications. In cases in which the infection is successfully combated, the zonal area of irregular rarefaction disappears, bone regeneration takes place between the sequestræ, and eventually the osseous continuity is restored. However, there remains an irregularity both in contour and density to mark the site of the infection (Fig. 5).

In the second type of spread, there is also a characteristic appearance upon the roentgenogram. The progression in this instance is along the diploic channels or the veins of Berchet, and the dissemination occurs more rapidly than in the spread by continuity. Early in such a case, there will be noted small areas of rarefaction along the course of the diploic channels. They have somewhat the appearance of venous lakes but are usually smaller in size and follow the vascular pathways more closely. Furthermore, comparison with previous roentgenograms when available show them to be of recent origin. The bone between the venous channels appears to be entirely normal. One may not recog-

nize this appearance as a manifestation of a spreading osteomyelitis unless the condition is fairly marked. However, in subsequent examinations when the infectious foci have become larger, the nature of the condition is readily recognized (Fig. 6). These small areas of involvement may subsequently serve as foci from which larger areas may become affected, although the infection may remain fairly well localized along the veins of Berchet. As has been previously recorded, osteomyelitis tends to spread upward toward the vertex. This is well illustrated in those infections spreading along the diploic channels (Fig. 6). When the condition responds favorably to therapy, the areas of rarefaction along the venous channels gradually disappear and eventually the bone returns to normal leaving no trace of the previous infection. When the affected areas are fairly large, bone regeneration occurs, producing the same irregularity in contour and density as previously described.

Occasionally an isolated area of osteomyelitis makes its appearance quite remote from the primary focus without apparent involvement of the intervening bone. The infection in such instances usually spreads by way of the venous channels, the secondary focus resulting from an infected thrombophlebitis. The roentgen characteristics of the secondary lesion are the same as those already described.

In the well established case of spreading osteomyelitis, it is extremely difficult from the roentgenogram to know precisely the pathologic changes which are taking place. When the involved area becomes extensively moth-eaten in appearance, one cannot be certain whether the irregularly shaped particles of bone represent sequestræ or viable portions of osseous tissue. Sequestræ are supposedly much denser in appearance, but from a clinical point of view it is best for the surgeon to determine the presence of sequestræ, requiring surgical attention, by the external manifestations of localized swelling or abscess formation. With surgical drainage of such areas, the underlying sequestræ will either be extruded or can readily be removed. Likewise, when an osteomyelitis is regressing, it cannot be definitely determined from the roentgen appearance whether the areas of rarefaction seen upon the roentgenogram represent active or inactive foci of infection. This can best be determined from the clinical signs and by a study of serial roentgenograms.

It must be admitted that in osteomyelitis of the skull the roentgen examination leaves much to be desired. The fact that the roentgen manifestations do not appear until one week to ten days after the actual infectious invasion is a serious handicap in the detection of the condition at a time when a precise diagnosis is most earnestly desired. This may permit the infection to gain such headway as is often difficult to overcome. It must also be borne in mind that the actual area of involvement is an inch or more beyond that shown in the roentgenogram. This fact must be taken cognizance of in any surgical attempt to completely excise the affected bone. The difficulty in the recognition of sequestræ and remaining areas of infection already referred to further detracts from the value of the roentgen examination. In the successful management of a case of osteomyelitis of the skull much depends upon the clinical manifestations. Nevertheless, the roentgen examination is an extremely valuable adjunct, and when used in conjunction with the clinical aspects offers a distinct aid to the surgeon in solving the many difficult problems presented by this serious condition.

It is not our purpose to discuss the treatment of osteomyelitis of the skull, but our roentgenologic observations impress us with the seriousness of this condition and the difficulties to be encountered in the therapeutic management of such cases. It has seemed that no routine method of treatment, whether conservative or radical, can be employed with success in every case. The futility of surgery at times has suggested to us the possible value of roentgen therapy in this condition. We have used irradiation in several cases but our experi-

ence is not sufficient to permit of its evaluation as a therapeutic agent in this disease. It was employed in one of the severest cases of osteomyelitis of the skull that we have ever encountered. This patient is making a remarkable recovery, whether because or in spite of roentgen therapy cannot be stated. The modern trend today is toward the treatment of all varieties of inflammatory lesions by roentgen irradiation, and it is entirely possible that this form of therapy may have much to offer in osteomyelitis whether it involves the skull or other portions of the skeleton.

SUMMARY

(1) It has seemed desirable to record and emphasize the roentgen manifestations of osteomyelitis of the skull, since this phase of the subject has received but scant attention.

(2) A résumé is given of the modern concepts of the etiology, pathology, and clinical aspects of the condition, since a knowledge of these is essential to a full appreciation of the roentgenologic manifestations.

(3) Roentgenologically, there is recognized two distinct forms of the disease, a localized and a spreading variety.

(4) The roentgen appearance of these varieties are described on the basis of their etiology. The condition may be secondary to paranasal sinusitis or mastoid disease, or may be metastatic or traumatic in origin.

(5) The limitations of the roentgen examination are discussed.

(6) Roentgen therapy is suggested as an adjunct to the modern method of treatment of osteomyelitis of the skull.

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ARTHROKATADYSIS OF THE HIP JOINT[1]

(REPORT OF FIVE CASES)

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THIS imposing name, meaning "subsidence or sinking-in of a joint," was suggested by P. J. Verrall (1), of London in 1929, for a peculiar condition of the pelvis which was first described by Otto, in 1824. The characteristic feature is an intrapelvic protrusion of the acetabulum and the head of the femur.

One of the earliest articles in this country was written by Philip Lewin (2), in 1924, who reported a case under the title of "Osteo-arthritic Protrusion of the Acetabulum." Prior to this, 38 cases had been reported. Pomeranz (3), in 1932, using the name "Intrapelvic Protrusion of the Acetabulum (Otto Pelvis)," gives an extensive review of the literature, stating that 79 cases had been previously reported and adding six of his own. Cary and Barnard (4) report two cases, stating that they prefer the name "arthrokatadysis," as it more accurately describes the condition. An additional case is reported by Reed (5) in July, 1933. Walter Mercer (6) in his textbook, "Orthopedic Surgery," describes a case by the same title in his chapter on chronic arthritis. Schaap (7), Golding (8), and Gellman (9) each report a series of cases during 1934.

The condition is characterized by a protrusion of the acetabulum into the pelvis and a narrowing of the joint space. This is apparently the end-result of a localized destructive process in the hip joint affecting essentially the acetabulum, resulting in softening and thinning of its wall. The deformity is evidently the result of weight-bearing and muscle pressure; the femoral head, pressing against the weakened acetabular floor, literally bores its way into the pelvis. The great trochanter approaches, and finally may impinge against the ilium, while the lesser trochanter comes closer toward the ischium. The hip joint is thus markedly deepened, its motion restricted, and the extremity shortened.

This yielding of the acetabulum may perhaps be considered analogous to the condition sometimes seen in chronic arthritis of the knee joint, in which the inner tibial condyle becomes depressed by the pressure of the overlying inner femoral condyle.

This is not a specific disease. The etiologic factors in the cases reported in the literature have been quite variable, including osteo-arthritis, gout, gonorrhea, syphilis, tuberculosis, trauma, and endocrine disturbances. In a personal communication, Mercer tells us that he believes the case he described was due to toxins of the tubercle bacillus, *i.e.*, Poncet's disease. Pomeranz suggests that it may be an "atypical but essentially non-specific arthritis of the hip joint."

Schaap believes that some of these cases may be ascribed to a congenital anomaly in which the acetabular cavity is too deep.

The condition has been seen most often

[1] Preliminary Report read before the Chicago Orthopedic Society, March 12, 1934.

in middle-aged females, and, in the majority of the reported cases, unilateral. The symptoms are those of a progressive chronic

Fig. 1. Case 1. D. S., aged 55 years, showing bilateral arthrokatadysis. The acetabula are definitely thinned, while the spherical shape of the femoral heads is preserved. Some hypertrophic change is seen in the head of the right femur.

arthritis, and the roentgenograms are characteristic, revealing a deepening of the acetabulum, with thinning of the medial and inferior wall, considerable eburnation, and narrowing of the joint space due to absorption of cartilage.

Conservative treatment with diathermy, radiant heat, massage, traction, and salicylates may give symptomatic relief, and occasionally plaster spica casts or braces may be used. If pain and disability persist despite these measures, arthroplasty or arthrodesis may be performed in properly selected cases.

CASE REPORTS

Case 1. Mrs. D. S., a housewife, aged 55, widowed, was seen on July 29, 1933, complaining of generalized joint pains and stiffness of two years' duration, involving especially the hips and knees. The symptoms were worse in the morning and were aggravated before rain. The bowels were regular with the aid of mineral oil. Several teeth were missing but the remaining ones were negative clinically and roentgenologically. The tonsils had been removed one and one-half years previously without influencing the joint symptoms. There was no story of sinus infection or gall-bladder disease. The patient had not lost any weight. She had gone through the menopause at the age of forty-eight.

She had had mineral baths, mud baths, colonic irrigations, diathermy, massage, fever treatment, and twelve injections of vaccine without relief.

The patient was able to walk but a few short steps and that with considerable difficulty. It was also very difficult for her to roll over when placed on the examining table. The essential findings were a marked limitation of motion in both hips, being worse on the right side. Flexion and extension were present to a slight degree, but rotation and abduction could not be performed. There were bilateral contractures of the knees (at 170°) with effusion. The hands were typically arthritic. The

general physical examination was otherwise essentially negative except for a moderate degree of pyorrhea. Urinalysis, blood count, and blood chemistry were normal. The Kahn test was negative. Roentgenograms of the hips (Fig. 1) showed definite bilateral arthrokatadysis. The roentgen report reads: "Bilateral intrapelvic acetab-

Fig. 2. Case 2. M. W., aged 71 years; arthrokatadysis of the left hip. The intrapelvic protrusion of the head of the femur is seen distinctly (*a*) with the great trochanter approaching the ilium, (*b*) Shenton's line is definitely broken and (*c*) the lesser trochanter is above the level of the ischium.

Fig. 3. Case 3. B. R., aged 59 years; bilateral arthrokatadysis, more marked on the left side. Note the peculiar hypertrophic changes of the left acetabulum and femoral head.

Fig. 4. Fig. 5.

Fig. 4. Case 4. C. M., aged 45 years; arthrokatadysis as the end-result of Neisserian arthritis.
Fig. 5. Case 5. The characteristic bulging of the acetabulum is seen; the patient was 38 years of age. In this case, however, there is marked sclerosis and thickening of the acetabular floor as compared with the preceding cases. There is also some hypertrophic change involving the ischial spine, which may be callus formation following an acetabular fracture.

ula. Bilateral arthritis with extreme narrowing of the joint spaces and condensing bone reaction. Spur formation, right."

The patient was in the Michael Reese Hospital from July 26, 1933, to Aug. 9, 1933, where she received massive doses of salicylates and intensive physical therapy, consisting of diathermy, radiant heat, and massage. The stiffness of the hips was markedly improved, but some of the pain and swelling of the knees persisted. On discharge from the hospital, the patient's gait was definitely improved.

Case 2. M. W., a housewife, aged 71, was seen in Mandel Clinic, Michael Reese Hospital, on Aug. 12, 1932. She complained of pain in the left hip and knee for six years, becoming progressively more severe. She stated that fifteen years ago she had fallen down several stone steps and injured the left hip and knee region, which was discolored for two months. The hip was painful for some time, but the patient was never confined to bed. After this she felt well up to six years ago when she noticed a gradual onset of pain in the left hip on walking. This became progressively more severe, so that for the previous two years she walked with the aid of crutches in order to relieve the painful hip from weight-bearing. The pain seemed worse in rainy weather. Radiant heat therapy gave temporary relief. Recently she began to have pain in the left knee and in both arms from the shoulders down. The patient was com-

Fig. 6. Case 3. Same patient as shown in Fig. 5; post-operative. Roentgenogram showing resection of marginal osteophytes from the head of the femur.

pletely edentulous. The throat was negative. The bowels were constipated.

The essential findings on examination were a 30° flexion deformity of the affected hip, with pain on attempted passive extension. There was tenderness over the great trochanter and over the left sacro-iliac joint. The Fabere sign was strongly positive, there being marked limitation of abduction and rotation. The left lower extremity was 2 cm. shorter than its fellow. The knees and shoulders revealed a moderate amount of crepitus but had a good painless range of motion.

The roentgenograms (Fig. 2) showed a definite picture of arthrokatadysis of the left hip joint and an osteo-arthritis of the right. The roentgenologist's impression was that of an old central fracture of the left acetabulum.

Case 3. B. R., a housewife, aged 59, applied for orthopedic treatment at Mandel Clinic on Oct. 25, 1931. Her chief complaint was pain over the lateral aspect of the left thigh of ten years' duration. This was associated with stiffness of the left hip. She also noted pain in the left knee and right thigh, worse on change of weather. Two years previously an attack of arthritis involving the left hip had been relieved by physical therapy.

The teeth were all absent. The tonsils were atrophic. The patient had chronic constipation with a story suggesting cholecystitis. She had had an essential hypertension for some time; her blood pressure at this time was 190/110.

Examination revealed an obese female, limping to protect the left hip. The lumbar lordosis was exaggerated, and there was spasm of all of the muscles about the left hip. There was a 20° flexion contracture of the hip, and a range of flexion of from 160° to 135°. Abduction was fair but no adduction or rotation was present.

Roentgenograms revealed bilateral arthrokatadysis with extensive hypertrophic changes involving the left hip.

Treatment consisted of radiant heat, diathermy, and massage, together with the usual palliative medication and weekly injections of Crowe's polyvalent vaccine.

Little change was noted under this régime, the patient continuing with some complaints throughout 1932. In April, 1933, however, she reported her pain as much diminished and was advised to continue with physiotherapy.

Case 4. C. M., a male, aged 45, developed an acute destructive arthritis of the right hip in April, 1929, about five weeks after the onset of an acute Neisserian urethritis. Treatment consisted of traction, followed by immobilization in a double plaster of Paris spica. Physical therapy was begun two months later, but the joint gradually stiffened so that only a slight degree of motion remained. In March, 1933, measurement revealed one-half inch of shortening of the right lower extremity, and roentgenograms showed definite intrapelvic protrusion. The patient had, however, very little disability and walked with a slight painless limp.

Case 5. J. S., a male, aged 38, was seen at the outpatient orthopedic clinic of the Cook County Hospital in March, 1935.

About one year previously, he had injured his left hip in making a quick leap forward to avoid being struck by a truck. He had never been bedridden, but complained of persistent pain in the groin which radiated down the thigh anteriorly to the knee, becoming gradually worse.

Examination revealed a good range of anteroposterior motion in the hip joint, but pain on attempted abduction. The roentgenogram showed sclerosis and intrapelvic protrusion of the acetabulum and hypertrophic changes in the femoral head and acetabulum.

Conservative measures of physical therapy and salicylates failed to give him relief from pain. A modified arthroplasty was performed on March 24, 1935. Through a straight antero-lateral incision, a muscle-splitting exposure of the head and neck was accomplished. The excrescences of the margin of the head of the femur were chiselled off. The patient made an uneventful recovery, and was discharged walking with crutches within two weeks from the date of operation. He has been observed in the outpatient clinic five weeks from the day of operation with a normal range of painless motion.

104 South Michigan Avenue

CONCLUSIONS

1. Arthrokatadysis, or "sinking in of a joint," describes accurately the condition known as Otto pelvis, or intrapelvic protrusion of the acetabulum.

2. It is not a disease entity, but is a structural deformity due to a localized malacia of the acetabular floor.

3. Five cases are reported.

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SOME LAWSUITS I HAVE MET AND SOME OF THE LESSONS TO BE LEARNED FROM THEM[1]

(THIRD INSTALLMENT)

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THEY PAID FOR AN OLD OSTEO-ARTHRITIS

THIS was an instance of a woman occupant of a rapidly speeding automobile which ran into a street car that had the right of way and was crossing a boulevard. Suit was filed against the corporation operating the street car. The writer was called by the defendant to testify as an expert witness. The trial occurred in 1925 before a jury of average intelligence.

While there may have been some question as to the liability, there was no question as regards the injury—she certainly was not injured.

After qualifying me as an expert in roentgenology, direct examination was begun by defendant's attorney. The questions are omitted, but may be inferred from the answers.

A. The film marked "Plaintiff's exhibit A," which I hold in my hands, is a roentgenogram or x-ray film of a human thorax (except the upper portion) and a part of the abdomen. The lower nine dorsal vertebræ are normal, or nearly so, in outline and form, except that the lower four of them have what we call osteophytes at the angles of the bodies.

A. The intervertebral discs are the soft cartilage portions of the spinal column which render it flexible. These are cushions between the bodies of the bones.

A. Osteophytes are the result of more or less constant inflammation, usually in some other part of the body. They are made up of bony or calcific deposits upon the angles of these bones. In this film they are on four vertebræ. There are similar exostoses or bony or calcific deposits on several of the ribs.

A. I also note that the heart is somewhat enlarged to the right and left in that portion called the ventricles. This enlargement is probably due to the same cause, that is, a long-standing chronic disease.

A. There are also some calcific deposits in the lungs. These are calcified glands, which are probably the result of early childhood disease.

A. The film marked "Exhibit B" is evidently a roentgenogram of the thorax, showing a diagonal view of an adult female. In the bodies of the vertebræ in this film, the osteophytes or calcific deposits show much more clearly, because we see the anterior or front surface of the bodies of these bones. The angle is probably exaggerated in this view, and the deposits show somewhat larger than they really are. Normally the outline is slightly rounded, and these places in this film are angular and sharp. The so-called angle of the bodies of the vertebræ is increased by the deposits.

A. I can see this deposit on the bodies of five vertebræ in this film.

A. No, there is nothing abnormal about the height of the bodies of the vertebræ.

A. I mean what is ordinarily known as lipping. That is a term used by those who handle these roentgenograms and make diagnoses from them—x-ray specialists.

A. Lipping, or increase in the angles of the bodies of the vertebræ, is present in five of them. It is on the upper angles of some of them and on the lower angles of all the upper four lumbar vertebræ as well as on the last or twelfth dorsal.

A. Exhibit C shows the lumbar vertebræ, the coccyx, sacrum, and part of the pelvic bones, the ilii. The coccyx is apparently tilted slightly to one side. There is lipping at the junction of the sacrum and

[1] The Editor desires to state that the questions and answers herein are transcriptions of court reporter's notes and have to be printed in form as received, without normal punctuation or phrasing. As printed, they serve to show the nature of court testimony although they do violence to grammatical rules.

ilium. This lipping is also seen in four places on the right side and noticeably on both sides of the lumbar vertebræ.

A. There is a slight amount of lipping on the upper border of the body of the five lumbar vertebræ, and on the lower borders of the lower four lumbar vertebræ.

A. That lipping is a deposit of calcium, due to and the direct result of a generalized, or systemic infection in the body of the individual of whom these roentgenograms were made.

A. In Exhibit D, I see a lateral view of the foot of an adult human. It is a pretty good sized foot and there appears to be no decided departure from normal.

A. Exhibit E shows an adult human foot, the film made from above downward. This shows an abnormality of the outer sesamoid bone under the great toe.

A. Probably this abnormality of outline is due to the same cause as the deposits on the bodies of the vertebræ, if this film was made from the same individual.

A. There is an excessive calcific or bony outgrowth on the sesamoid bone, making it much broader and more angular than normal.

A. There is also some lipping of the edges of the external cuneiform bone, indicating that this deposit or series of deposits is a generalized condition, appearing as it does on the back bones, the pelvis, and the foot. This film also shows some deposit on the ankle or shin bone.

A. This is marked "Exhibit F." Yes, it shows some of the same sort of deposit as do the other bones.

A. In speaking of a generalized condition, I mean that it is a condition found in various parts of the body, as far as these films show.

A. Yes, probably every bone in this individual's body has some of this same kind of deposit upon or within it.

A. I would say that the nature of this generalized condition, in simple terms, is what is commonly called rheumatism or a rheumatic condition.

A. The deposit is made of a material which looks like bone. It is not true bone but it looks like bone. It has not the fine structure of bone but is built up of thin layers of calcium. It is harder than bone, will chip and break like bone.

A. No, these x-ray films show no bones which have been fractured by external violence, except that in the film which shows the coccyx.

A. The condition of the coccyx may be due to its having been fractured.

Q. Can you tell, assuming that these x-ray pictures of the foot were taken just a few days ago, and the pictures of the backbone and the pelvis, Exhibits A, B, and C, were taken in May, 1923, of a woman about thirty years of age, an opera singer, opera singer for several years, and by "several years" I mean at least nine or ten years or something like that, and she was in an automobile collision with an electric street car in August, 1922, about a year and a half ago—about two and one-half years almost; down on her hands and knees on the bottom of a machine, in the back part of an automobile which had had a collision with a street car, a pretty severe collision, but the machine was not tipped over, and she was not thrown out; she remained on her hands and her knees on the floor of the car, and the automobile ran 75 or 100 or 150 feet and went into a window, stopped right side up, and she was dazed and unconscious for a little while, and they took her in another machine and went over to the hospital, and she became rational, called for her husband before she went to the hospital, and when she got in the hospital she was examined by a surgeon of the hospital; he was a graduate physician senior interne at the time, he having graduated about a year before in his profession; he went over her and made an examination of her, and found no fractures; her husband was in the hospital and she went into the same room with her husband and stayed there in that same room with her husband, with him about five days and then she left the hospital. The first day she was up, sitting in a chair, a wheel chair; one day she walked into the lavatory, toilet room of the hospital, without any assistance, and in five or six days she rode home in a machine; her bowels

moved and the function of the bowels and bladder were normal and natural. Also that is the x-ray picture of her coccyx taken at the time I told you. Would you be able now to form an opinion as to whether that coccyx was fractured in that accident or not?

A. I would be.

Q. What is your opinion?

A. My opinion is that that coccyx was not fractured in that accident.

Q. Assuming that this woman before August, 1921, had not had any serious accident or illness; that is, nothing that she recognized as such, and that she kept right on with her regular work all the time. In fact, she has kept with it since, and is now engaged in it; she had no acute attack of any kind prior to August, 1921, to cause her discomfort or pain in the back or the region of the coccyx itself, not enough so that she would recognize it. Taking that all into consideration, would you be able to express an opinion, Dr. Trostler, whether this inflammatory condition or arthritis or whatever name you gave it—what is the name you gave it?

A. We call it, when it occurs in the joints, arthritis, and when it occurs in the backbone we call it spondylitis. Osteo-arthritis will cover the whole thing.

A. Yes, I have an opinion as to whether that change in the coccyx occurred prior to August, 1921; my opinion is that it existed prior to that time, because if it had been fractured any time within her adult life, there would not be the bony union there is now. In case there had been a fracture in that coccyx during comparatively early childhood, it might have united and formed in the position shown in the film.

A. Fracture of the coccyx in adult life does not heal and unite to the structures just above it, as shown in that film.

Q. Now, Doctor, sometimes a person who has these germs of infection in their system, if they are in an accident, although there may be no fracture, but a severe wrenching and strain, and bruises may, if these germs are in the system, may, on account of the lowered resistance, and so forth, may cause these to localize and commence an osteo-arthritis. Is that right?

A. That is right.

Q. What I am trying to get at is this: Now from the history I just gave you a few minutes ago, are you able to give an opinion as to whether the accident described, owing to the presence of germs in the body, set up an arthritis since Aug. 27, 1921, or whether the arthritis itself, or the deposits or the spondylitis, whichever terms you gave to it, existed prior to Aug. 21, 1921?

A. I think that that deposit existed for not less than five years.

Q. Not less than five years?

A. Not less than five years and probably longer than that; considerably longer than that.

Cross Examination by Plaintiff's Attorney

A. This indicates a general rheumatic condition. If she came to me, I would send her to some other physician who would prescribe for her. That is outside of my line of practice. I seldom prescribe medicine, except in conjunction with x-ray treatments, or in patients from outside of this city who are staying for treatments.

A. Yes, I am a physician, but I specialize in radiology and most all of my patients are referred to me by other physicians.

A. Yes, I can tell from these films, without any more history of the case than that just given to me, what the minimum period would be, during which this condition of the spine must have existed. The minimum period, with the amount of deposits shown in this film, would be greater than two years.

A. Yes, I have talked with Dr. Leeming. I first saw him or some one in connection with this case last Thursday noon; I saw the films at that time.

Q. So that the jury has that correct. Don't you understand that if it appeared that this bone deposit existed before this accident, this company would not be to blame, and if it appeared that it existed after this accident, this company may be to blame?

A. My testimony is not whether anybody is to blame or not. I am testifying as to what I see in these x-ray films and what my training, experience and the knowledge gained from these, show me and indicate to me. I have no knowledge of any accident, except what was given me in the hypothetical question.

A. I do not know whether it is material to show whether these conditions existed before the accident or only after it.

A. Nothing was said to me about compensation for this opinion.

A. Compensation was not mentioned because I did not feel called upon to ask about it.

A. Yes, I have testified for them before. I have testified for you also.

A. Certainly, I expect to be paid for my services; but it was not mentioned until you brought it up.

A. I was called here by a Mr. Stewart, over the telephone last Thursday.

A. Yes, I talked with Dr. Hubeny.

A. Dr. Leeming and Mr. Stewart were both present when I examined the films. I do not remember who handed them to me.

A. I told Dr. Hubeny what I saw in the films, and we agreed that we both saw the same things, last Thursday afternoon.

Q. You insist that the coccyx never heals?

A. The coccyx when fractured during adult female life, never heals spontaneously.

A. Yes, that is why I say that the coccyx in the film shown me, if fractured at all, must have been fractured in childhood.

Q. If fractured at all?

A. Yes, if fractured at all. There are so many anomalies in the spine, and the coccyx is one of the spinal parts, that this may be one of the not at all rare anomalous variations from the normal.

A. No, not at all. No, I do not know that it is the commonest thing in the world to fracture a coccyx and have it heal in a corrected position. It is not nearly as common as is the lack of knowledge of human ailments by some attorneys I know.

A. The coccyx does not heal in adults, who are up and about.

A. A person—man, woman, or child—cannot sit down in comfort with a fractured coccyx, a broken coccyx.

A. The junction of the sacrum and the coccyx is a flexible joint.

Q. Is it not a fact that any two bones in apposition will grow together?

A. I take it that you mean any two fragments of a broken bone. If that is your meaning, my answer is "No, if they are not so immobilized as to be held constantly in apposition." It is not at all unusual for fractures not properly immobilized to heal by fibrous union, forming a false joint.

Q. Suppose you were wearing a specially constructed thing, a great big rubber band, eight inches wide, so that you won't sit on the coccyx, then it might unite.

A. I can imagine that it might, yes.

Q. Then your argument that because it is grown together in adult life proves it never was fractured, wouldn't work, would it?

A. My statement is based upon experience, study, and the knowledge of medicine and surgery and the records of same.

A. It is my opinion that a fractured coccyx will not unite in an adult female.

A. If the coccyx shown in the film under discussion has been fractured, it is my opinion that such fracture occurred in early childhood.

A. No, there is no shortening of the vertebræ. No evidence of shortening.

Re-direct Examination

A. I said that there is no visible evidence of shortening of the bodies of the vertebræ in the films.

A. That observation is based upon the study of many hundreds of bodies of human vertebræ, and comparison with each other in the films examined.

A. Yes, every time the bowels act, the fragments of a broken coccyx move.

A. Yes, that is one of the very important causes for the failure of a fractured coccyx to heal or unite. The reason they might or do unite in childhood, is because all bones heal more readily in childhood.

A. Yes, I expect to be paid for coming

here. I do not know what my charges will be for coming here.

Dr. M. J. Hubeny was sworn, qualified and testified, verifying the testimony of the writer in practically every detail.

The attorneys for the railroad company felt practically sure that the plaintiff would secure a verdict, and advised settlement. This was done. It was, however, just another instance of a hold-up, "because one person had a gun and the company had the money." Such instances of "hold-up" are more common in the courts than on the highways. A big corporation or rich individual practically never gets a square deal before a jury.

IS A ROENTGEN DERMATITIS ON A PHYSICIAN'S HANDS ACCIDENTAL?

A little more than a year ago I had an inquiry from one of the best known radiologists in Canada, reading as follows: "There is a young doctor in my district who has a small office x-ray equipment. During the past ten years he has frequently abused his hands by frequent exposures without proper protection. As the result he has developed a radiodermatitis with multiple keratoses and several ulcerations. During the past six months he has spent a great deal of time in the East . . . ., at which time he had two fingers amputated as the result of the extensive tissue involvement.

"This young man carries an accident and sickness policy in an insurance company. He interviewed me recently with a view to obtaining an opinion as to whether I thought I could say that his incapacity was the result of multiple accidents. What is your opinion? Are there any cases on record of which you have any knowledge whereby the courts have ruled that injury to the operator's person was considered as accidental and whereby the insurance company have assumed the responsibility and liability?"

My reply was as follows: "Replying to yours of the 21st inst. relative to the doctor who had exposed his hands to the x-rays and developed a radiodermatitis, and as to the accident liability, will say that much depends upon the wording of the insurance contract or policy.

"Personally, I cannot see how any such injury, by even the greatest stretch of legal interpretation, could be considered as an accident or due to accidental means.

"The legal definition of what is an accident or accidental has not often been the subject or theme of leading high court decisions, as far as I know; but such as I do know of, state it in a fairly clear manner. One such (Lickleider *vs.* Iowa State Travelling Men's Assn., 166 N.W.R., 363) says that an accident is 'an event from an unknown cause or an unexpected event from a known cause; a thing done or disaster caused without design or intention; an unusual or unexpected result attending the performance of a usual or necessary act.'

"That decision further goes on to state that 'An injury happening to an insured person through his own voluntary act, is not an accident nor is his hurt to be attributed to accidental means . . . . and it is true, that if the insured does a voluntary act, *the natural, usual and to be expected result of which is to bring injury upon himself, then a death so occurring is not an accident in any sense of the word, legal or colloquial.*'

"Now then, you know and I know, and the other man should have known, *and the insurance company will have no difficulty in proving by a great preponderance of the evidence* (or at least testimony), that such an injury as a radiodermatitis is *not* the unusual or unexpected result of the exposures; but *is in fact, the usual and expected* result of the exposures, even though the injured man did not know that, so it seems to me that the element of accident is and should be eliminated and discarded.

"But, it may be, that because this man's injury was without design on his part, or that it happened without the concurrence of his will, that your Canadian courts may consider that part of the injury as accidental; but I do not believe that he would have any chance of proving the injury as accidental in the United States.

"I am enclosing a reprint which contains the above case decision, as well as some

others that may be of interest. I call your attention to . . . . *vs.* . . . . . case, in which I was involved as an expert and helped plan the prosecution of the case for the widow. I knew her husband, Dr. . . ., very well personally and took a great deal of interest in it and, of course, derived a great deal of pleasure and satisfaction out of the final victory for Mrs. . . ., besides receiving considerable praise from several sources as the result of my activity in the case. The insurance company fought hard and long, using all the tactics which high priced lawyers can and will use. They had me on the witness stand three times and grilled me, or rather tried to grill me, to the extreme, but I was sure of my ground, and did not contradict myself once in the hours that the lawyers propounded their questions. I did not get a nickel for my services, but the experience was worth much to me in the satisfaction of a deed well done and justice furthered.

"Another case which might be considered to apply in the one you mentioned, is Herwig *vs.* Business Men's Accident Assn. of America (234 S.W.R., 853). That is a Missouri Supreme Court decision, which holds that the insurance association was not liable when the plaintiff, *a physician*, was not immediately disabled by an accident.

"Another case, in which the court said that an occupational disease is not an accident, might be applied. That is Peru Plow and Wheel Co. *vs.* Industrial Commission *et al.*, an Illinois case reported in 142 N.E.R., 546.

"I am sorry that, as far as my experience goes, your friend has little chance for recovery from the insurance company. If they do pay him or are forced by court procedure to pay him, will you let me know about it?"

I have not heard that any payment or settlement was made.

AN ECZEMA CASE

A Southern radiologist of considerable prominence wrote me: "I have been sued, charged with burning a man's legs with x-rays. I would like to purchase a good book on the subject, for the benefit of my lawyers. What have you to suggest? I understand that you have made an exhaustive study of the subject. Have you anything that you prepared that I could get?"

My reply read: "I am in receipt of yours of the 21st and replying will say that I wish you had given me more particulars relative to the matter in hand, and then I might have advised you more intelligently, from the very start.

"However, I take it that there will be plenty of time for you to send me such details as seem advisable, for me to advise you, before the case comes up for trial.

"Your understanding that I 'have made an exhaustive study of the subject' is correct. I have studied the subject because I like it, and you know when we like a thing we go into it thoroughly. I would *rather* help fight a malpractice suit *than eat*. But as every malpractice suit or claim is as different as is every clinical case, every one must be handled differently, and without a pretty good knowledge of the entire matter little valuable advice can be given, unless we have made an examination. I am enclosing (on another sheet), a list of questions, which, when answered, will give me sufficient insight to say something about how best to prepare your defense. You must know that every case, no matter how apparently trivial, *must be well prepared*, in order to win. Without proper preparation, the best and surest case may be lost. I do not want to brag but I am sure that your attorneys will say that the man who drew up the questions on enclosed sheet knows something of planning a fight in court.

"You ask for the name of 'some good book on the subject.' I am sorry to say that I know of none that I think is really good enough to completely cover it. A recent book gotten out by the Macmillan Co., entitled 'Courts and Doctors,' by Lloyd Paul Stryker, late attorney for the New York State Medical Society, is about the best that I know of. It is inexpensive and I advise you to get it. If you want, I can order it here for you. George M. MacKee's 'X-rays and Radium in the Treatment of

Diseases of the Skin' (Lea & Febiger, 1927 Edition) contains about ten pages on 'preparation for trial' and 'defenses' that are pretty good."

The questionnaire that I sent (with this physician's answers) follows:

Age of patient? 36. *Sex?* Male.

Disease or condition treatment was given for? How long standing? Eczema of lower legs. About three years' standing.

Technic used and dates of treatment? 80 kvp., 2 ma., 16 inches F.S.D., 7 minutes. [*Note:* He failed to mention filter.] Nine treatments in all from April to October, 1925, two to four weeks apart.

Date of last treatment? Oct. 22, 1925.

Have you complete and accurate records of the treatments? Yes.

When were these records made? At time of treatment. *By whom?* By me.

By whom were the treatments administered? By me.

What was the effect of the treatment? No visible manifestation.

When did patient first complain of injury? The night of the last treatment.

Of what did patient complain? Excruciating pain in the parts treated.

Have you or anyone in your employ or association admitted to the patient, his relatives, or attorney that an error has been made, or, in other words, have you (or has anyone for you) in any way *acknowledged liability for the alleged injury?* No.

Are you insured against malpractice? Yes. *With what company?* U. S. F. & G. Co. *Amount?* $5,000.00. *Have you notified the insurance company?* Yes.

Does plaintiff in this case know that you are insured? Yes.

If reported to insurance company or state society, will you send me a copy of your report to them? I made a verbal report at last meeting. [*Note:* He answered this question only in part.]

Can you send me a copy of plaintiff's bill of particulars or his charges against you? Yes.

Has plaintiff paid his bill? Yes. *Any part of it?* All. *Does he dispute the bill?* No. *Has he refused to pay it?* Paid it. *Has he made any promises to pay it?* [Blank.] *Have you any witnesses to a promise to pay the bill?* [Blank.]

What is occupation of plaintiff? Farmer. *Has he a good reputation?* Yes. *Is he liked or disliked in his community?* I think he is liked.

Had he been to other physicians before *you treated him for the condition complained of?* Yes.

Has he been to other physicians since his alleged injury by you? Yes.

Does plaintiff belong to any important fraternal organizations? Mason.

Is he a lodge brother of yours? Not in same lodge.

Will the trial of the suit come up in your home town? Yes.

How soon? Next October. *When was suit filed?* Last month.

How do you stand in your home town among the laity? Good, if I tell it.

How do you stand in your home town among physicians? Good, if I tell it.

Do you now hold or have you held any offices in your local or state medical society? I am on Jurisprudence Committee in state society.

Do you now hold or have you held any political office? No.

Will any of your local medical confrères appear as witnesses against *you (as witnesses for the plaintiff)?* No. *Are such as will do so, of high standing?* [Blank.]

Will any of your local confrères appear as witnesses for you? Yes.

Have you made any arrangements for expert witnesses? Yes. *If you have, who are they?* Dr. W. F. H....., of New Orleans, and others from Memphis. *Do you own the ..... Hospital?* No. *If not, what is your position there?* I am radiologist.

Is that hospital classed as a charitable or municipal hospital? The hospital was, at the time of his treatment, owned by a stock company, for profit. It is now owned by a stock company but 'non-profit.' "

Upon receipt of the foregoing I replied: "From a mere scanning of the information you gave me in the questionnaire, it is easy to see that your technic is well within the bounds of safety, even though you did not inform me as to whether you used any filtration or not. There is ample in the information to show a proper application of the radiation, and as radiation is proper treatment for eczema, you should have no difficulty in proving that to the jury and also that it is a physical unlikelihood that the patient was damaged by your treatment. In fact, I feel sure that you were not guilty of malpractice, and that you should not have very much difficulty in convincing a jury that you were not guilty, even if the case cannot be taken from the jury by the presiding judge, which seems altogether likely.

"But with all this, it is sometimes not

understandable how a jury of apparently sane and sensible men, will render a verdict for the plaintiff in such cases. I have seen verdicts rendered in the face of the most evident and clearly manifest proper practice and good treatment, given against some of the highest thought of and most erudite physicians. So you must prepare to fight it to the last ditch, as if you were sure of losing unless you fought with the last erg of your strength. Eternal vigilance is surely the price of liberty here, more than in any other place I know of."

This suit was settled out of court for less than it would have cost to try it. While it was a bad precedent to make in settling a malpractice suit, I can hardly blame those interested.

X-RAY TREATMENT OF A SYPHILITIC RASH!

About eight years ago, a physician in a north-central State wrote me that he was being sued for malpractice because of alleged injuries produced by the x-rays. He also stated that he had not notified his insurance company.

I sent him the usual questionnaire so that I might have more or less complete information of matters as they were, from his standpoint, and upon its receipt, wrote him as follows:

"In regard to the suit you say is pending, will say that, as far as I can determine, from the meager particulars you gave me regarding the technic of the treatment, you have 'not a leg to stand on' as regards an effective defense in the affair.

"While I am radically against settling such cases, there is, from your description, sufficient indication that the x-rays have produced an injury, and as the x-rays are not an approved method for the treatment of the skin manifestations of lues, you will probably have a difficult time to convince any judge or jury that you did right in treating plaintiff in the manner you describe.

"If you had either shown proper skill or exercised due care in the application of that skill in the treatment of the case, there might have been some hope for a good defense, and a favorable verdict likely in the case, by alleging or claiming hypersensitiveness of the skin or idiosyncrasy or possibly neglect to follow your instructions (as you allege) by the plaintiff, etc. These items would, however, be futile, in the presence of the fact that you treated him for a condition wherein your methods were not in accord with the usual, customary, and regular practices as followed by recognized medicine.

"In reply to your question as to whether plaintiff 'has any damage when he didn't return for observation or treatment,' will say that 'returning for observation or treatment' *would not have made an iota of difference in the end-result. You could not in any way have modified the end-result after the treatment had been administered, no matter what you might have done.* In other words, the damage was done at the time of your administration of the treatment, and *not* by the patient's failure to return. The greatest error was made by your treating the patient *at all* for a luetic rash, in the first place; and in not using filters in the second place. Filtration is necessary in cases where repeated dosage is applied on the skin. It probably would have, as it generally does, prevented skin atrophy, which is what this man has, from your description.

"So, in view of these decidedly damaging points, it seems to me that the wisest course for you to pursue will be to settle as cheaply as you can, and be more careful in the future.

"If you had been paid cash for this treatment, you would probably not have been sued. Lawsuits are frequently the result of a long delayed demand for payment. I have had one myself that had been hanging fire for several years—and was absolutely unjustified as far as injury is concerned—thrown out of court recently. That suit was started because I handed the bill for a balance due on my fee, to a lawyer for collection.

"You are certainly unfortunate in not having read your contract for malpractice insurance, so that the insurance company

would protect you. That again is, of course, your own fault, although, in my opinion, the sharp practice of the insurance company in refusing to defend you in this case because you had delayed reporting the filing of the suit is *inexcusable*. I know that the company where I carry my insurance would not act in that manner.

"I am sorry that I am unable to give you any advice that will help you beat this case; but if you finally decide to fight it, I will be glad to outline such points and manner of defense as I can for you. In that event, you must, of course, let me have the exact technic you used, dates, and all the particulars you have in the matter. Of course, your attorney should have all the dealings with the claimant or plaintiff, so that you do not compromise yourself, in offering a settlement.

"If your attorney is inclined to fight this case on its merits, show him this letter and see what he says after reading it.

"I will be glad to learn from you the final outcome of this case, and trust that it will not cost you very much."

Evidently this physician did not like the tone of my letter, because he failed to reply. I wrote him a follow-up letter about a year later; but up to this time have not heard how the suit was disposed of. If he reads this, and I have reason to believe that he will, I wish he would inform me.

A PLANTAR CALLUS "ET UX" CASE

Just about ten years ago I was consulted by a very good friend from central Iowa relative to my aiding him in defending two damage suits. The physician defendant was a man of highest standing and attainments, a past-president of his state medical organization, and one of the early users of the roentgen rays in his vicinity.

The plaintiffs in the suits were a lawyer and his wife, the latter having been the patient and alleging that she had been damaged by the physician defendant because of roentgen treatment to a large plantar callus.

The bill of particulars set up charges that the x-rays were not an approved method of treatment for the condition, that because of the treatment, infection occurred under the callosity, that much time had been lost, atrocious and agonizing pain resulting, and necessitating an expensive trip to a large clinic, where it was alleged (but not proven) that a diagnosis of x-ray burn had been made, etc., *ad nauseum*, as only a lawyer can describe in polysyllabic phraseology; and for all this, the good doctor should pay the trifling sum of $20,000.

The husband (an attorney) alleged that his mental anguish, the loss of his wife's companionship, etc., was worth another $20,000, so he also sued the doctor for that amount.

Both sides of these suits were well prepared and well represented by plenty of legal talent and the trial was consequently long drawn out by the introduction of much unimportant testimony, as well as frequently interrupted by extended legal arguments in efforts to sustain or controvert objections raised by one or the other litigant.

I attended the trial as a consultant and expert witness for the defendant physician. My testimony was to the effect that roentgen rays were an accepted and approved method for the treatment of plantar callosities, that the dosage applied was safe, proper, and in every way correct, and that if any infection or consequent abscess occurred under the callus, it was in spite of the correct roentgen treatment and not because of it. None of my testimony was disputed, except by the plaintiff and her co-plaintiff husband, and that was only by hearsay statements (which they managed to sneak in) of what they alleged was told them at the big clinic.

After dragging through four days (which should have been accomplished in one day), the jury rendered a verdict for the physician defendant.

The next day, the suit brought by the lawyer husband of the patient wastried and ended in another verdict for the defendant.

The appreciative defendant, a friend of the writer for many years, wrote me—in part—as follows: "I am told that my

friend, Judge M. . . . (one of his attorneys who had telegraphed me 'Jury decided in favor of Dr. H. . . . We are much gratified and are very grateful to you for your services and assistance'), has already sent you word of our victory in the suit.

"Of course, I am pleased to have it come out so. It seemed to me that the trial judge was fair in his charge to the jury, although I could not claim that our side received any special favors. The entire case, of course, depended upon the question as to whether there was an x-ray burn and, if so, was it due to my negligence; but your testimony was so convincing and given in a manner that every one present felt that you knew what you were talking about. My attorneys say that they like the way you talk to the jury.

"I want to thank you most sincerely for the great favor of coming to . . . . at great inconvenience, loss of time, etc., to assist me. Your services were invaluable. The attorneys used your testimony with confidence, in their arguments both for a directed verdict—which we did not get—and to the jury.

"This was my first experience in court, except as a witness, and after spending a good part of three weeks in the trial, I must say that I am not specially taken with it."

Both of these cases were appealed by the plaintiffs and the Supreme Court of Iowa confirmed the judgments of the lower court.

The winning of these two cases gave me more pleasure than did the winning of any other suits I have been interested in, *my own included*.

THE BIG LAWYER WAS FLUSTERED

In 1908 I was a witness for the State in a rape case and was being cross-examined by a very prominent attorney with whom I was quite well acquainted. This attorney was a very large man and was known to be extremely abusive to opposing witnesses. Our acquaintance did not prevent his applying some of his severest abuse to me.

He had asked me some question to which I had replied, "I do not know," at which he pretended to become very much incensed. Roaring loudly at me, he shook his long index finger under my nose, so close that I could feel the wind stirred up by it; he continued in his apparent attempt to embarrass and browbeat me.

Unabashed and not at all afraid, I stood this for quite a while. Then I gently pushed his hand away from in front of my face and quietly but distinctly said, "Mr. O'D. . . ., if you do not take your finger away from under my nose, I will bite it."

My remark and the accompanying action caused all present to shout with laughter and somewhat startled the big, blustering lawyer. After the bailiff had restored order, I said, "On second consideration, Mr. O'D. . . ., I do not believe that I will bite your finger. It is too dirty," which again caused those present to be convulsed with laughter.

I was excused and the court declared a recess. The big lawyer affectionately put his arm across my shoulder and we walked out together. He assured me that he had never been so disconcerted in his life and he told the story as a good joke on himself several times in my presence.

But, in the final summing up of the testimony in the case, my friend called the attention of the jury to the fact that one of the State's witnesses was so hostile to his client that he threatened to bite his finger.

(To be continued)

PULMONARY SYPHILIS IN ADULTS, WITH REPORT OF A CASE

By W. W. ROBINSON, M.D., *Memphis, Tennessee*

IT IS generally agreed by internists and pathologists alike that the lungs of the adult are relatively immune to syphilitic infection. This is a rather strange concept of a disease as protean in its symptomatology and as diverse in its pathologic manifestations as is syphilis. Hutchinson has remarked that syphilis has long been said to constitute in itself an epitome of pathology. Yet, it appears that it rarely attacks the lungs of adults. While it is true that it is seldom recognized or suspected during life, undoubted cases have been reported. In 2,800 autopsies at the Johns Hopkins Hospital (1) there were 12 cases found, but only four of these in adults. Three of the 12 were recognized clinically. Among 20,000 patients admitted to the Munster Clinic, Krause (2) observed only five cases. Dienst (3) has reported five cases, two of which were unquestionably authentic. Golden (4) has described three cases of massive interstitial fibrosis of one whole lung occurring in syphilitic individuals, which condition had existed for several years, and in which there was cavitation with retraction of the heart and other mediastinal structures. Watkins calls attention to the possibility of this type of case being the result of a syphilitic tuberculous symbiosis. Ordinarily, in uncomplicated syphilis of the lung, cavitation occurs only in the terminal stages as a result of bronchial dilatation and bronchiectasis, and calcification is never noted. Moreover, it should be remembered that such fibrosis may develop from other inflammatory processes. It should not be classified as of syphilitic origin unless spirochetes are demonstrated in the lesions. It does not compare with the massive interstitial consolidation, or white pneumonia of infants, in which there is ample pathologic evidence of its syphilitic etiology. Allison (5) has reported a case of irregular consolidation of the left lower lobe, present for several years without symptoms or signs in a syphilitic, which was undoubtedly proven by its complete disappearance in a few weeks after institution of specific therapy. Hartung and Freedman (6) have reported three cases, one of miliary gummas, and two of the solitary variety, all of which are authentic. These clinicians specify certain criteria for a diagnosis of syphilis of the lungs which are well worthy of mention. The patient must have a syphilitic history, with the signs and symptoms of a chronic, stubborn, progressive pulmonary lesion, a sputum negative for the presence of tubercle bacilli on repeated examinations, positive serology, and a definite lesion demonstrable roentgenographically, which should show an unquestioned response to anti-syphilitic medication. The diagnosis is made more positive if the lesions are more extensive than the condition of the patient would indicate.

There are no pathognomonic lesions in syphilis of the lungs. They are a late manifestation of the disease, usually appearing two to three years after the initial infection. Whereas they are said to have a predilection for the middle lobe of the right lung according to Köhler (7), or according to other authors they preferably affect the hilum zone of one lung-field, or the base of one lung, the distribution of the lesions and their appearance is quite variable. In a disease giving rise to such diverse pathologic processes there can be no typical roentgen picture. Roentgenologically, the following three types of lesions have been described:

(1) According to Assmann, there is a generalized thickening of all the bronchial markings, studded with minute "knobby" enlargements, radiating out from the hilum into one or both lung-fields, and producing a characteristic fan-shaped effect, a diffuse interstitial fibrosis of the bronchial tree. If bilateral, this lesion may be confused with the infiltrative type of metastatic

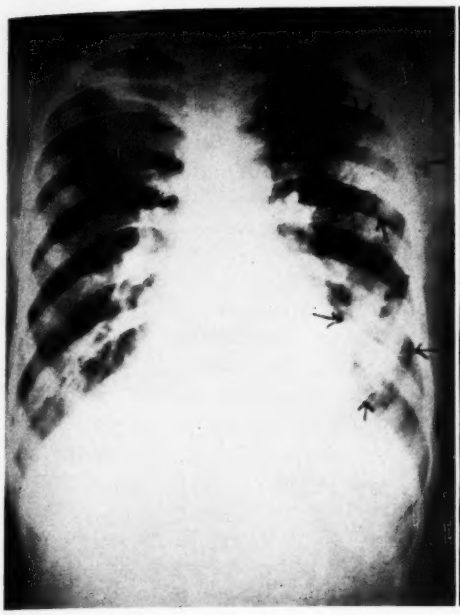

Fig. 1. Original roentgenogram of chest. Note lesions in left upper and lower lobes, and their similarity to lobular tuberculosis and abscess formation. The infiltration in the lower lobe shows a rarefied center.

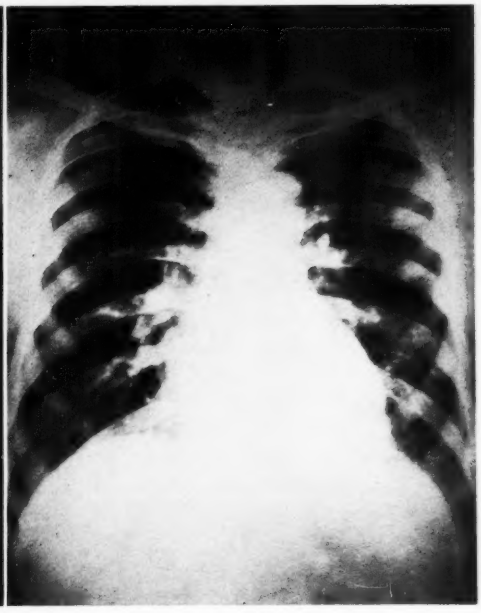

Fig. 2. Roentgenogram of chest, taken ten days after the fourth dose of neosalvarsan. Note the marked regression of both lesions.

malignancy. If unilateral, primary bronchogenic carcinoma of the infiltrating type must be excluded. The process may be confined to comparatively small areas, found more especially in the hilus of the lung. There is marked cellular invasion of the interstitial connective tissue, the walls of the vessels and bronchi, and later a hyperplasia of the connective tissue and desquamation of the epithelium of the alveoli.

(2) Gummas of the lungs, which may be miliary and multiple, or solitary discrete masses several centimeters in diameter, appearing as nodular areas of increased density usually near the hilus, or even in the periphery of the lung-field. In the early stage of development of the latter, a delimiting zone of pneumonitis is formed about them, which is replaced in the later stages by a fibrous connective tissue capsule. They may become necrosed, demonstrated by an area of rarefaction in the central portion of the nodule. Instead of necrosis, fibrosis may occur. In the early stage of the solitary type, especially if situated in the periphery of the lung, the condition may be confused with a lobular tuberculosis or abscess formation. In the late stage of encapsulation, and located near the hilus, it resembles a primary malignant tumor. The miliary gummas may be mistaken for metastatic malignancy.

(3) The diffuse lobar form, which is occasionally described as a distinct entity, should not be classed as such because the lesion itself is probably in the primary bronchus, and the picture is one of a secondary massive atelectasis resulting from a broncho-stenosis.

Symptoms and signs may be absent. They are quite variable, and are usually dependent on the nature and extent of the lesion. They may be manifested by a dry trivial cough, or the expectoration of a muco-purulent sputum, with febrile reactions and all of the signs of an active tuberculosis. A sudden and severe hemoptysis may be the first symptom. In

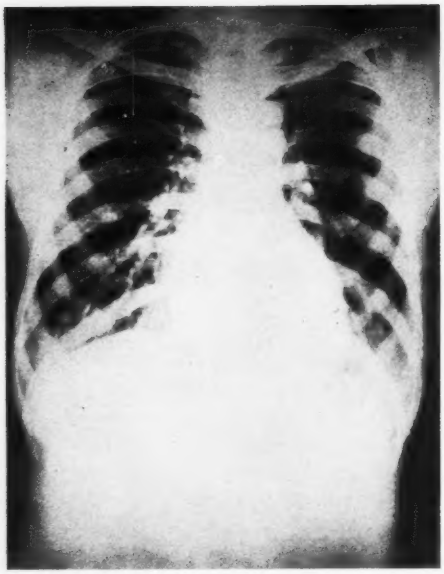

Fig. 3. Roentgenogram of chest, taken several months after the treatment was completed. Both lung-fields are entirely free of any pathology.

a case of syphilitic tuberculous symbiosis with a sputum positive for tubercle bacilli, most certainly an associated syphilis of the lung would never be suspected. Many cases are, therefore, entirely overlooked, or confused with tuberculosis or tumors of the lung parenchyma, which fact would tend to account for the rarity of the disease.

Case 1. I. S., negress, aged 36 years, employed as cook in a home, entered the clinic on July 16, 1932, with the diagnosis of pulmonary tuberculosis.

Family history: Irrevelant.

Marital history: Married twice, one child by first husband, aged 20 years, living and well, and one miscarriage by second husband, occurring three years before this examination. Second husband was thought to have pulmonary tuberculosis, but had been treated for syphilis for several years.

Menstrual history: Periods irregular, prolonged, and accompanied by much pain in the lower right quadrant.

Past history: She had had the usual juvenile infections, also influenza in 1918, but no respiratory complications. There had been attacks of so-called rheumatism and myalgic pains in various parts of the body, as well as indigestion for a period of two years. It was significant that she had been treated for syphilis for three years. Inquiry into this gave the impression that the treatment was inadequate in every respect.

Present illness: This began two months before admission to the clinic with severe pain in the left side of the chest, pleuritic in character, irregular fever, ranging from 99° to 100° F., highest in the afternoon, and accompanied by night sweats and the expectoration of a muco-purulent sputum. She felt weak, but her appetite was good, and she continued to work. Apparently she had lost no weight.

Physical examination: This revealed a well-developed, well-nourished, colored female with a typical serpiginous nodular syphiloderm over the posterior aspect of the neck, shoulders, upper arms, lower back, and upper gluteal regions, which was bilaterally symmetrical in its distribution. She stated that this eruption had been present for several months. It was not accompanied by itching. There were shotty glands in both axillæ, also in the inguinal regions. The epitrochlears were not palpable. The deep and superficial reflexes were normal. The eye, ear, nose, and throat examinations were essentially negative but for some hypertrophy of the tonsils. The thyroid gland was not enlarged, and no cervical glands were felt. In the chest, fine, moist crepitant râles were heard in the left axilla and lateral half of the left infraclavicular region, but all other physical signs were negative. Examination of the abdomen showed nothing of any significance, except some tenderness in the lower right quadrant. Pelvic investigation revealed some tenderness in the right fornix with slight induration, uterus of normal size, and in its normal position.

Laboratory examinations: Several sputum tests were negative for tubercle bacilli. No Vincent's organisms were found. A urinalysis showed a mild albuminuria. The leukocytes were 8,400; differential count—

polymorphonuclears, 48 per cent; lymphocytes, small, 30 per cent, large 20 per cent; eosinophiles, 2 per cent. The blood Wassermann and Meinicke turbidity reactions were four plus positive.

Roentgen examination of chest (Fig. 1): The right lung-field was essentially negative, except for a moderate thickening and widening of the hilum zone. In the periphery of the upper left lobe, in juxtaposition to the axilla, there was a definite area of increased density and infiltration 4.5 cm. in diameter, with hazy, irregular margins. In the base of the lower left lobe adjacent to the cardiac shadow there was a similar area of increased density and infiltration with a rarefied center. The left hilum showed much thickening and widening, with extension along the epibronchus, but more especially along the infrabronchus. A few calcified glands were noted in either hilum. The tracheal, heart, and diaphragmatic shadows were normal.

Diagnosis: Late stage of syphilis, with the probability of infection of the left lung, gummatous in character, involving the upper and lower lobes.

Treatment: Four doses of neosalvarsan of 0.6 gram each were given at weekly intervals. No other treatment of any kind was used. There was a severe reaction to the first two injections, after which it was noted that the patient had no further rise in temperature. The cough was much better, and after the fourth treatment all cough had subsided. There was a striking improvement in all of the symptoms. The syphiloderm was rapidly disappearing.

Ten days after the last treatment, the chest was again roentgenographed (Fig. 2). Both of the lesions of the left lung showed marked regression. Only a vague opacity remained in the periphery of the upper left lobe indicating the site of the original lesion. In the lower left lobe only a few linear striæ of increased density marked the location of the previous infiltration.

An intensive regimen of anti-syphilitic treatment was instituted. There were no further symptoms or signs referable to the chest. Roentgenograms made several months later (Fig. 3) showed both lung-fields to be entirely free of any pathology.

COMMENT

An undoubted case of pulmonary syphilis involving the upper and lower lobes of the left lung has been presented. This case conformed to all of the criteria laid down for a diagnosis of syphilitic infection of the lungs. The response to specific therapy was prompt and lasting.

Attention is directed to the possibility of confusing such cases with tuberculosis or tumors of the lung parenchyma.

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RADIATION THERAPY OF FEMALE PELVIS FOR BENIGN LESIONS

WITH REPORT OF 396 CASES

By VERNOR M. MOORE, M.D., *Grand Rapids, Michigan*

THE radiation treatment of benign uterine hemorrhage, at or near the menopause, is not a new procedure. Many thousands of cases have already been reported, so that the status of radiation in the treatment of these conditions is known with fair accuracy. This report concerns the radiation treatment of 396 cases of uterine hemorrhage, with an analysis of the results, together with certain observations based on this experience. The discussion is not meant to be a comparison of radiation, surgery, and medical treatment. Some cases are found suitable for one method of treatment, some for another, and one may succeed in cases in which another has failed. It is, rather, an effort to evaluate the degree of success using radiation treatment alone.

Uterine fibromyomas are present and probably contribute to uterine hemorrhage in the greater percentage of cases. Klob (1) estimates that uterine myomas are present in 50 per cent of all women over 50 years of age, and in 20 per cent of all women over 35. Ewing states that "the essential etiologic factor in uterine myoma is an embryogenic disturbance of the structure of the uterus due to a disturbance in the formation of the tubes, uterus, and vagina from the Müllerian ducts which split off the Wolffian bodies at an early period and fuse to form the genital tract. . . . The relation of certain early myomas to the blood vessels of the uterus has long impressed many observers and suggested that uterine myomas arise from a disturbance in the growth of blood vessels from the walls of which the uterus and vagina originally receive their muscular tissue. Rosger, Sobotta, and others have traced the development of early myomas from the vessel walls and concluded that the blood vessels control the origin and growth of uterine myomas."

Radiation acts chiefly on the ovary and in adequate doses represses the formation of the Graafian follicle. It so acts because the germinal epithelium is among the structures most sensitive to radiation. The ovary as a whole suffers little damage, and after radiation appears normal in size and color. Nicotra (3) states that a histological examination of the uterine mucosa one or two months following radiation was normal. There is undoubtedly some action on the fibroid itself. Zimmern and Brunet (4) found the tumor to regress in response to treatment after the menopause, also after menses were again resumed. Furthermore, cervical stump fibroids respond well to x-ray therapy, even after the removal of the uterus and ovaries. There is probably very little action on the blood vessels in the dosages employed, and the action on fibroids probably does not depend on blood vessel action.

The effect is distinctly different in the event that the x-ray or radium is used. The radium is usually placed in the uterine canal, and its greatest action is local and fades off rapidly a few centimeters away from the source. On the other hand, x-rays treat the ovaries and the whole pelvis fairly evenly and do not produce the caustic effect which tissues adjacent to radium receive. Desjardins (2) states that either the x-ray or radium is a specific for benign uterine hemorrhage at or near the menopause not related to fibromyomas. Radium placed in the canal may produce bowel injury if there should be adhesions holding the bowel to the uterus. Action with radium great enough to affect the ovary produces more damage to the uterine wall than appears necessary. Most radiologists who have both x-rays and radium at their disposal prefer x-rays on account of their more gentle action and their greater effect on the ovary (6).

In general, the indications for radiation are in those cases of hypermenstruation be-

tween the ages of 35 and the menopause, in which the uterus is not larger than a four months' pregnancy and is not complicated by ovarian cysts or other adnexal disease. Larger fibroids may be radiated if there are contra-indications to surgery, often with brilliant results. However, the larger and harder the fibroid the less chance of complete regression of the tumor and the greater the percentage of poor results. Various complications of fibroids have been given as contra-indications to radiation. Among these are co-existing ovarian cysts, pedunculated and submucous fibroids, incarcerated fibroids, desire for future pregnancy, adnexal inflammation, and unusually large fibroids, etc. These are valid contra-indications with the exception of chronic pelvic inflammatory disease. This condition is not considered unsuitable for radiation; on the contrary, this experience includes cases in which radiation has definitely improved the condition and in no case has the inflammation become aggravated by it. Submucous pedunculated fibroids should be removed surgically. Desjardins (2) advises treatment with radium when they are small. Surgical removal followed by radium to the base is, in my experience, good treatment when submucous fibroids are found. Large incarcerated fibroids are best treated by removal. It is noteworthy that few, if any, ovarian cysts have come to operation after this treatment, and one case which, after consultation, was considered to have an ovarian cyst had no trace of it following treatment. Follicular cysts as a rule disappear, and seldom recur. However, a case complicated by the presence of an ovarian cyst of diagnosable size is considered unsuitable for treatment. In cases before the age of 35 a myomectomy would appear indicated or, if desired, a temporary menopause by radiation may be induced. Incapacitating dysmenorrheas in women under 35 have been relieved by temporary sterilizing doses. When menses return, the patient usually comes again for another treatment. The amenorrhea usually lasts about one year. If there are no bad effects and the patient so wishes, the second treatment may be large enough to make it permanent. In producing a temporary amenorrhea, the patient should be aware that a permanent amenorrhea may follow; this has not occurred in any case of this series except when done intentionally. It is particularly liable to follow if subtotal removal of both ovaries has been done beforehand by surgery. If myomectomy has been done and symptoms still persist radiation may be used.

The plan of treatment used in this series is, first, to select suitable cases by careful history and physical examination. These include fibroids, which are intramural or subserous and not pedunculated, in patients between the ages of 35 and the menopause. Cases with ovarian cysts or fibroids over three months' pregnancy in size should be excluded, unless surgery cannot be done. The symptoms usually are menorrhagia without intermenstrual spotting. In the second group will be cases of menopausal dysmenorrhea; these may have fibroids or subinvoluted uteri, and the latter may be normal in size. The third group will be fibroids in patients under 35 years of age. An occasional case may be treated as young as 33. A temporary amenorrhea may be produced by a half dose, but a myomectomy or radium in the uterine canal would appear preferable. Patients under the age of 35 with a severe menorrhagia or dysmenorrhea may be given a temporary sterilizing dose.

The treatment consists of x-ray therapy applied through four ports, over the pelvis. The factors are as follows: 200 kv. filtered through 0.5 mm. Cu and 1 mm. Al at 50 cm. distance are used to deliver from 600 to 650 r units per 15 sq. cm. field, and the central beam in each field is directed toward the ovaries. The total dose is given on two, three, or four successive days. The case is then observed by monthly examinations until the uterus has returned to approximately normal size; the patient is then discharged. If there is an abnormal response to radiation therapy, prompt surgical consultation is sought and a curettage is done to rule out corpus cancer. If found,

radium treatment, hysterectomy, or both are done. Most of the failures in this series have been due to failure to recognize carcinoma of the fundus. These may occasionally be overlooked even after a diagnostic curettage has been done (5). Theoretically, these cases should be excluded from the series, because by having a routine diagnostic curettage beforehand the majority of them should be found. Our reason for not having it done is largely on financial grounds, as it has been more expensive to the patient to have it done than the entire cost of radiation. We would recommend it in every case, to find the two or three cases of cancer in each hundred admissions if the chances for recovery in these two or three were seriously jeopardized by a two to three months' delay. However, carcinoma of the fundus grows slowly and is not prone to metastasize early, and radiation should tend to repress its growth even though inadequate in amount. For these reasons, if no unusual complications or suspicious symptoms are present, these cases have been treated first, and surgical intervention has followed as soon as any suspicions were aroused. Needless to say, if there is pain, intermenstrual spotting, or cachexia the diagnostic curettage is done before any radiation is attempted.

After radiation, the patient has not as a rule been more incapacitated than she was prior to treatment, and usually attends to her regular duties without interruption. After radiation, the patient usually experiences a moderately tired feeling, which wears off within a week or so. In some cases radiation sickness may be severe, but these symptoms are seldom alarming and in none has it been considered serious. The menorrhagia is not influenced for at least a month; in fact, many cases show an exaggerated menstrual flow at the next period. This is usually controlled by rest in bed. Transfusion is seldom, if ever, necessary. Some cases will not menstruate again after the treatment but the majority of cases will have one period and occasionally two. The fibroid does not show much reduction in size until one month after the last menstrual period. From then on there is a gradual reduction in size for several months.

No radiation accidents have occurred and no mortality attributable to radiation has resulted. Death has followed subse-

TABLE I.—RESULTS IN FIBROMYOMAS AFTER RADIATION

Size fibroid	Cases	Health good, pelvis normal after radiation	Patient well, last report	Carcinoma uterus	Surgery later	Good result
Walnut	23	18	3	1	1	91.3%
Egg	6	5	1	0	0	100.0%
Tennis ball	6	5	1	0	0	100.0%
Orange	42	34	7	1	0	97.6%
Grape fruit	59	46	8	3	2	91.5%
Larger than grape fruit	9	7	1	0	1	89.0%
Size not stated	99	79	14	3	3	94.0%
Total	244	194	35	8	7	94.6%

TABLE II.—RESULTS AFTER RADIATION IN MISCELLANEOUS GROUP

	Cases	Health good, pelvis normal after radiation	Patient well, last report	Recurrence	Carcinoma uterus	Surgery later	Good result
Dysmenorrhea	86	66	15	1	2	2	94.1%
Endometriosis	1	1	0	0	0	0	100.0%
Endometritis hyperplastic	3	3	0	0	0	0	100.0%
Pelvic inflammation	1	1	0	0	0	0	100.0%
Menopause artificial	2	2	0	0	0	0	100.0%
Menorrhagia	26	20	6	0	0	0	100.0%
Metrorrhagia	19	16[1]	3	0	0	0	100.0%
Sterilization	4	4	0	0	0	0	100.0%
Subinvolution	10	7	3	0	0	0	100.0%
Total	152	120	27	1	2	2	97.1%
Total all cases			396				

[1] One patient died from other causes.

quent surgical treatment of cancer of the uterine body due to the progress of the cancer, but whether the omission of a preliminary diagnostic curettage contributed to it is an open question. Certainly the radiation does not contribute to it, but the two months' delay before operation may have.

It is well known that the normal menopause does not appreciably change the sexual urge. It should be stressed at this point that radiation does not castrate or de-sex the patient any more than the normal menopause does. Carter (6) says: "The internal function of the ovary is not depressed more than by the normal climacteric." The ovaries in cases observed by operation after radiation—and one such case was so observed—are normal in size and color, but no corpora lutea are seen. Radiation prevents ovulation, and as a result the follicular hormone which activates the menstrual cycle is suppressed. This prevents stimulation of the fibroid by the periodic congestion of the menses, and thus reduces its blood supply. If fibromyomas come from the blood vessel walls, as many pathologists believe, it can be seen that this action should result in their regression, extending over varying lengths of time. Cases have been reported in which fibroids continued to regress so slowly that the uterus did not reach normal size until 15 years had elapsed. The average uterus will, if the tumor is not too large, reach normal dimensions in from one to six months after amenorrhea has been produced. If considerable anemia is present, it may take from six months to one year for the blood to regain normal hemoglobin, this depending on the severity of the anemia and the length of the illness. With the cessation of the menses, the blood picture begins to improve and there are as a rule no pelvic symptoms. A leukorrheal discharge may persist for a time but usually soon disappears. Hot flashes appear when the menses cease; they are rarely as troublesome as the natural menopause, and are decidedly less severe than when produced by the removal of the ovaries. Bowing states: "We know that the menopause brought on by therapeutic administration of radium or roentgen rays is less stormy than that produced by castration."

Patients as a rule do not gain in weight. Falls, in a study of 1,000 cases of goiter, found no definite relation between them and fibroids. He believes that hypothyroid patients tend to gain in weight after radiation, but that it can readily be controlled by diet. Other cases do not gain beyond the normal weight which they had before their illness. A few of the cases reviewed gained in weight, but these were hypothyroids, and their weight was easily controlled by diet and thyroid medication. Falls states that cases with fibroids and adnexal disease show no greater incidence of thyroid disease than the normal. The basal rate in 35 of his cases was slightly high, but was not considered significant. Nervousness is generally improved, and one case mentally sick was greatly improved, probably due to improvement in her general health. There is no evidence to show increased nervousness, in fact, the evidence points in the opposite direction.

Various complications which definitely contra-indicate radiation have been given, but these are about as infrequent as unusual complications in pregnancy, and while no records were kept of patients examined but not treated, this experience leads to the conclusion that probably nine out of ten cases are suitable for radiation at some time during the disease. Wintz, at Erlangen, treats 90 per cent of these cases by radiation. French gynecologists, according to Waters, operate on about 70 per cent, but if familiar with radiation divide them equally between surgery and radiation. The results in therapy after the menopause are not gratifying. Fibroids at that time are usually hard in consistency, and will usually go down slowly after repeated treatments, but the results in postmenopausal fibroids are not considered good.

Sarcoma is not thought to develop in fibromyomas as formerly believed, but to grow in another part of the uterus, coexistently or after a fibroid has been pres-

ent. Norsworthy states: "Reports are published in which fibromas of apparently simple structure have destroyed life. These reports, however, should be accepted with the knowledge that the uterus is occasionally the seat of true sarcomas which in their early stages present symptoms clinically characteristic of fibromyomas. There is no positive evidence on record that innocent fibroids take on sarcomatous degeneration unless complicated by trauma or infection."

While there are numerous contra-indications for radiation, the percentage of cases which cannot be treated is probably not over 15 per cent. This means that out of 100 cases ten will be rejected as unsuitable for radiation, while five will be treated and require surgery later. If a diagnostic curettage is done in every case, the two to four cases of carcinoma of the body of the uterus should be discovered. Our method then gives a poorer group of statistics than if these were excluded beforehand by a curettage.

SUMMARY

Total cases treated	396
Total fibroids	244
Total fibroids well after radiation	94.6%
Total miscellaneous group	152
Total miscellaneous group well	97.1%
Incidence of carcinoma fundus, fibroids	3.3%
Incidence of carcinoma fundus, miscellaneous group	1.32%
Incidence of carcinoma fundus all cases	2.5%
Fibroid cases requiring surgery after radiation	2.8%
Non-fibroid group requiring surgery after radiation	1.3%
Successful results all cases	95.8%

(1) While we have no records of the number of cases that refused treatment on account of contra-indications, it is believed that more than nine out of ten cases referred for radiation have been considered suitable for treatment, and the results, so far as they could be ascertained, are given on all cases so treated.

(2) This series fails to show any case of cancer of the uterus developing later. The experience in this review leads to the impression that uterine or cervical cancer is rare after such radiation, provided, of course, that it was not present originally.

(3) No primary mortality occurred in this series, and no serious later sequelæ have developed.

(4) It is our firm belief, based on a large number of inquiries, that the sexual lives of these patients are not appreciably changed by the radiation therapy. The term "x-ray castration" is emphatically disliked in describing this form of treatment.

(5) If a diagnostic curettage is done before radiation and cases of corpus cancer eliminated, radiation theoretically should have 2.5 per cent better results than these statistics show.

(6) Five per cent of cases treated may require surgery, to effect a good result. Surgery may follow radiation without any untoward effects, and the results in cases having both radiation and surgery should be the same as with surgery alone.

(7) In properly selected cases of benign hemorrhage at or near the menopause, x-ray therapy will produce satisfactory results in 95 per cent of cases.

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ROENTGEN EXAMINATION OF THE INTERCONDYLOID FOSSA OF THE KNEE JOINT

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From the Roentgenological Service of Dr. Max Cohn, and the Orthopedic Service of Dr. Charles M. Jacobs, of the Mount Sinai Hospital, Chicago

FROM a clinical standpoint, there are a certain number of cases which present definite intra-articular pathology of the knee joint, in which the roentgen films taken in the usual manner give little or no aid to the clinician. Thus, a view for the visualization of the intercondyloid space and the posterior compartment of the knee joint is essential; the idea was first suggested by Béclère, and later by Frik, in 1932. There are a number of scattered reports in the foreign literature, but we were unable to find any report in the American literature. The value of this view for the interpretation of intercondyloid pathology is so beautifully illustrated that it warrants its publication.

The anatomy of the intercondyloid fossa and its contents is an aid in understanding the value of this view for visualization of its contents in diseases. The lower third of the femur has two condyles which are separated behind by the intercondyloid fossa, this fossa being tilted at an angle of 60 degrees.

Anteriorly, the lateral condyle is wider and more prominent, while the medial condyle is narrower and longer to compensate for the obliquity of the shaft. When the femur is in the natural position, the inferior surfaces of the condyles are on the same plane and almost parallel for articulation with the upper surfaces on the head of the tibia. The two condyles are continuous in front, forming a smooth trochlear surface for articulation with the patella.

The opposed surfaces of the two condyles form the boundaries of the intercondylar fossa and give attachment to the crucial ligaments. The posterior crucial ligament is attached to the fore part of the lateral surface of the medial condyle, and the anterior crucial ligament to the back part of the medial surface of the lateral condyle (Morris). The synovial membrane also projects into the joint and is occupied by fat, which serves as a padding to fill the

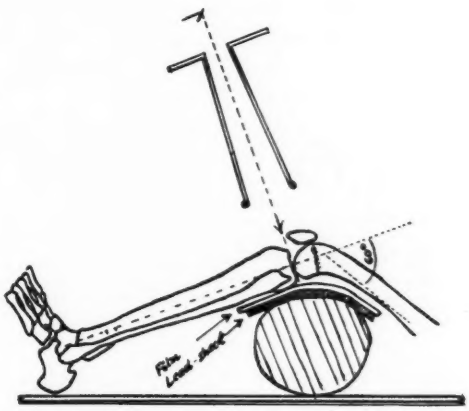

Fig. 1. Illustrating the technic for visualization of the intercondyloid fossa.

spaces. The chief of these processes—patellar synovial fold, or the ligamentum mucosum—arises from the infrapatella fat mass. This so-called ligament is the central portion of the large process of the synovial membrane, of which the alar folds form the free margins. It extends from the fatty mass below the patella backward, and upward to the intercondyloid notch of the femur, where it is attached in front of the anterior crucial and lateral to the posterior crucial ligament. This ligament becomes tense in flexion and serves to keep the pad in position when there is positive pressure in the joint (Fisher).

A roentgen film taken in the usual manner does not permit the intercondyloid space to be seen, because the anterior portion of the intercondyloid part of the femur is superimposed upon this space. Many

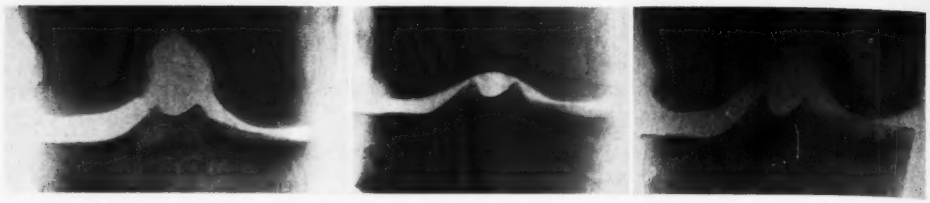

Fig. 2 (*left*). Normal intercondyloid fossa. Fig. 3-*A* (*middle*). Anteroposterior view, showing slight elongation of tibial spines. Fig. 3-*B* (*right*). Same case. There may be seen a definite elongation of tibial spines. Beginning calcification of the crucial ligaments.

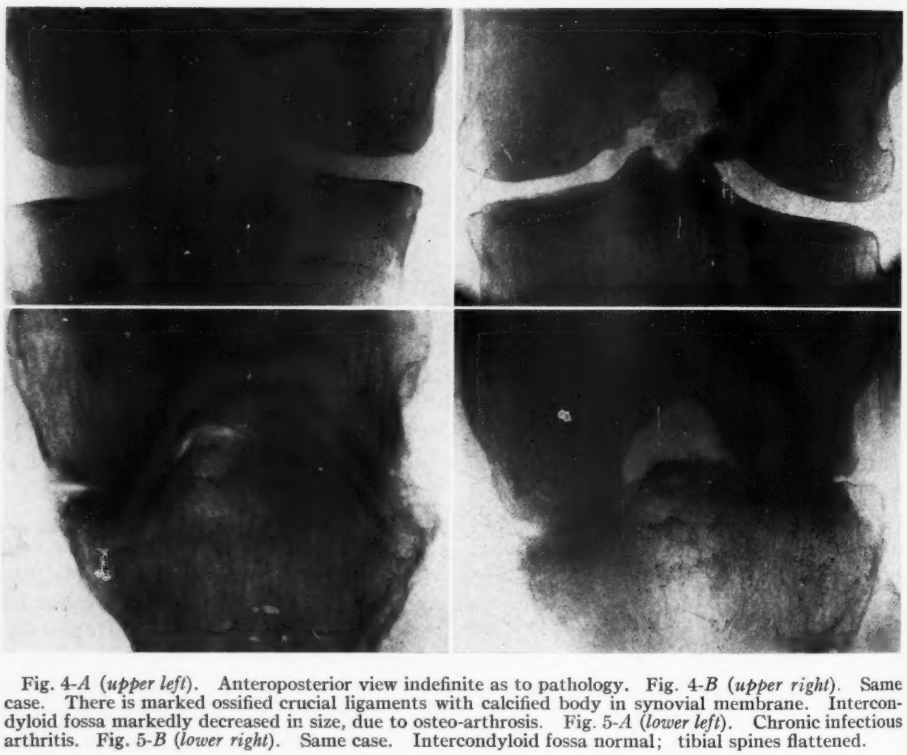

Fig. 4-*A* (*upper left*). Anteroposterior view indefinite as to pathology. Fig. 4-*B* (*upper right*). Same case. There is marked ossified crucial ligaments with calcified body in synovial membrane. Intercondyloid fossa markedly decreased in size, due to osteo-arthrosis. Fig. 5-*A* (*lower left*). Chronic infectious arthritis. Fig. 5-*B* (*lower right*). Same case. Intercondyloid fossa normal; tibial spines flattened.

times the spines of the tibia are partly covered by this portion of bone. In a special view, a normal knee (Fig. 2) reveals the space, semi-circular in outline, with its edges smooth and regular; the spines of the tibia are always visible, and the articulating surfaces of the tibia and femur are seen as well as, or better than, on the ordinary anteroposterior view.

The intercondyloid fossa can be visualized on a roentgen film by a rather simple technic. As the roof of the intercondyloid fossa is tilted for 60 degrees, thus we flex the knee joint for the same amount. For a more distinct detail, we do not use intensifying screens but a film wrapped in black paper, which is placed in good apposition in the popliteal space with the knee in a flexion of 60 degrees. It is advisable to use a lead sheet underneath the film in order to obliterate the back-scatter. The central ray is directed exactly below the inferior tip of the patella, and is perpendicular to the longitudinal axis of the tibia. A narrow

Fig. 6-*A* (*left*). Irregularities of the tibial spines may be seen at the base of both tibial spines.

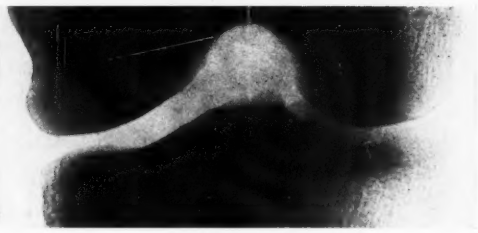

Fig. 6-*B* (*right*). Same case. Definite fracture line

conus should always be used. We must guard against movement of the leg, because we use an increase in our time corresponding to the lack of the intensifying screens. Figure 1 very clearly illustrates all the details of the technic.

It is not within the scope of this paper to give all of the pathology in our series of cases, but to present a number of typical pathological conditions which are best illustrated by this view.

On the film (Fig. 3-*A*), in the anteroposterior view of the knee joint, the beginning of a lipping is seen at the outer border of the tibial condyle and a questionable elongation of the tibial spines. In contrast to this, the special view (Fig. 3-*B*) illustrates clearly all that the anteroposterior view has given, plus some fine calcified striæ and spurs on the inner border of both condyles, which we have to interpret as calcifications in the crucial ligaments. The elongation of the tibial spines is much more pronounced and better visualized in its details.

In the anteroposterior view (Fig. 4-*A*), the joint spaces are clearly seen, and the contours of the articular surfaces are regular. The tips of the tibial spines are hidden by the condyles of the femur. There is an oval-shaped, calcified area seen at the base of the tibial spines. There is a lighter area of density in the lateral aspect of the medial condyle. The lateral view aids us little or none in the interpretation of this knee joint.

Looking at the special view (Fig. 4-*B*), it reveals a more extensive pathology; (1) One oval-shaped shadow, presenting bone structure, is seen in the middle of the intercondyloid space; (2) another oval-shaped shadow is seen over the lateral tibial spine, of homogeneous calcium density, which apparently corresponds to the shadow visualized on the other view; (3) elongation and irregularities of the tibial spines; (4) the intercondyloid surface of the medial condyle is markedly roughened. The medial portion of the intercondyloid space is partly filled by an irregularly limited bony projection, arising from the medial portion of the condyle. A gastrocnemius sesamoid is seen. The interpretation is an advanced calcification in the crucial ligaments, and a calcified body in the synovial membrane with a marked osteo-arthrosis deformans, which is evident in the intercondyloid fossa.

Figure 5-*A* shows all the typical signs of a chronic infectious osteo-arthritis of the knee joint. A special view (Fig. 5-*B*) reveals the intercondyloid space to be normal except for the tibial spines, which are flattened. It is quite interesting to compare this view of an infectious athropic arthritis with that of the osteo-arthrosis (Fig. 4-*B*).

Figure 6-*A*, in the anteroposterior view, reveals a narrowing of the joint space and some irregularities of the tibial spines, which are superimposed with the patella. A definite interpretation of this film is difficult. The lateral view, however, reveals a tearing off of one of the tibial spines which is practically obliterated by the condyles of the femur. The special view (Fig. 6-*B*) definitely shows a fracture line at the base of the tibial spines, and both tips of the spines appear torn.

SUMMARY

The anteroposterior view of the knee joint may only give a limited knowledge of the underlying pathology, while the flexed position enables one to visualize the knee joint in greater detail. It is our plea that this view should always be used when vague intra-articular disturbances are present. The reasons are, first, that pathology, if present, is more sharply demonstrated, and second, that no elaborate apparatus is needed.

The visualization of calcified crucial ligaments, calcified interligamental bodies, and erosion of the surfaces of the intercondyloid borders of the femur may aid in the differential diagnosis of internal derangement about the knee joint.

This paper has been limited to the anatomy and roentgen technic of the intercondyloid fossa, with presentation of only a few cases. At a later date, we will attempt to give a more complete survey of the correlation of the symptoms and pathology of the intercondyloid fossa.

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DISCRETE PULMONARY LESIONS, ROENTGENOLOGICALLY CONSIDERED

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IT is an undisputed fact that the roentgen examination of the chest is a distinct aid in the diagnosis of pulmonary disease, particularly so in conditions which manifest themselves as discrete lesions, some of which are so small that they are frequently overlooked on ordinary physical examination. It is also true, however, that the nature and differentiation of these shadows cannot always be recognized on the roentgenogram alone, yet if they are correlated with all the clinical and laboratory data, a proper interpretation of the pathologic condition may be made.

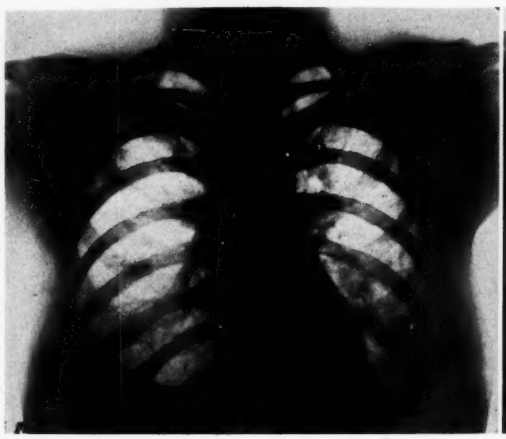

Fig. 1. Round foci type of pulmonary tuberculosis.

Fig. 2. Exudative type of tuberculosis; calcified.

Discrete pulmonary lesions appear on the roentgenogram as variously sized, isolated, more or less circumscribed areas of increased density. Many of these disease processes have been described by Sante. These discrete shadows are manifestations of some of the following pathologic processes:

Round foci type of tuberculosis;
Exudative type of tuberculosis;
Miliary tuberculosis—acute, chronic, and healed;
Miliary bronchopneumonia;
Embolic pneumonia;
Miliary malignancy;
Pneumoconiosis;
Secondary sarcoma and carcinoma;
Hodgkin's disease;
Leukemia;
Niemann-Pick disease;
Nodular gummatous syphilis;
Pulmonary cysts;
Lobular atelectasis.

Recently, Albert, Fraenkel, and Straub have called attention to a type of pulmonary tuberculosis occurring as isolated, sharply defined, coin-sized, round, encapsulated shadows with no reaction of the surrounding tissue. They may develop with or without fever and with positive or negative sputum. These foci may remain stationary for years, even in the presence of a progressive or fatal tuberculosis elsewhere. They may eventually pro-

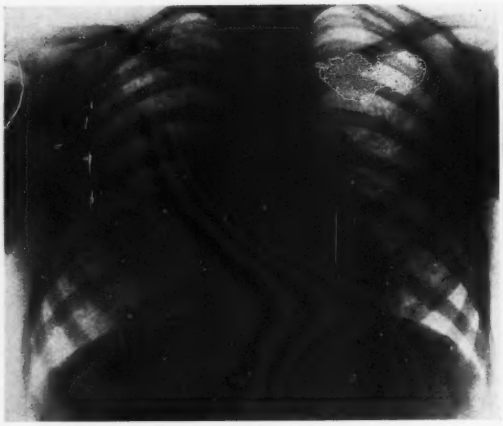

Fig. 3. Miliary tuberculosis.

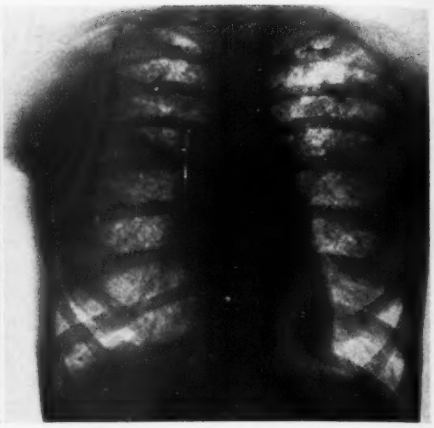

Fig. 4. Sub-acute dissemination of pulmonary tuberculosis. Original lesion at the base of the right upper lobe.

Fig. 5. Diffuse nodular tuberculosis (autopsy). First diagnosed as metastatic malignancy.

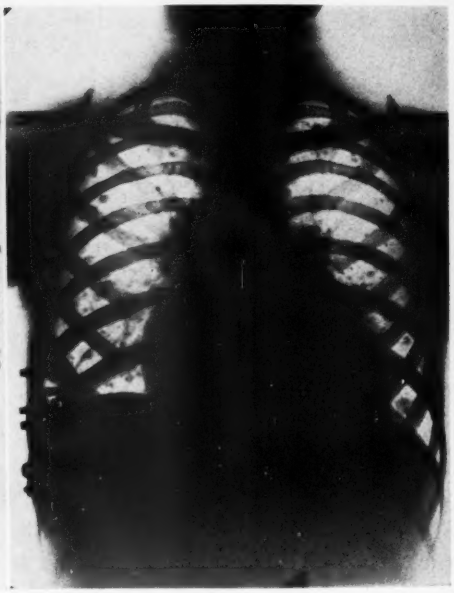

Fig. 6. Diffuse calcified metastasis (osteogenic sarcoma of right femur).

gress, however, and go on to liquefaction and cavitation, extending into the surrounding tissue by the formation of daughter foci. These lesions constitute a rare form of development of exudative focal tuberculous inflammation isolated by a connective tissue capsule.

Owing to the rarity of round foci of a tuberculous nature, one has great difficulty in differentiating them from tumor metastases, which very commonly appear as round pulmonary shadows. They may also simulate non-tuberculous bronchopneumonia, syphiloma, cysticercosis, and echinococcus cysts. The clinical history plays a most important part in the differential

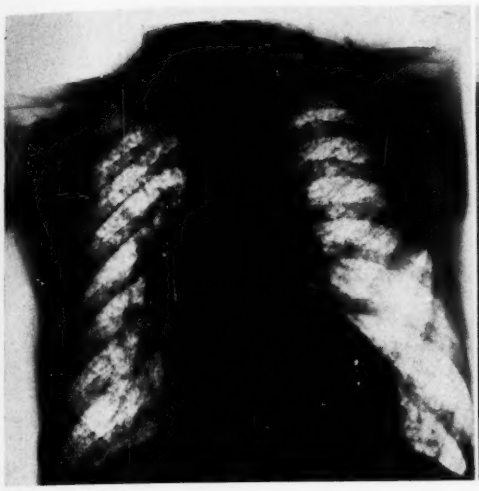

Fig. 7. Pneumoconiosis, second stage.

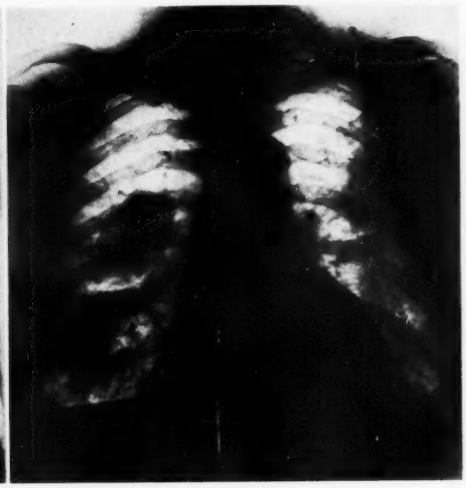

Fig. 8. Silicosis; more advanced stage.

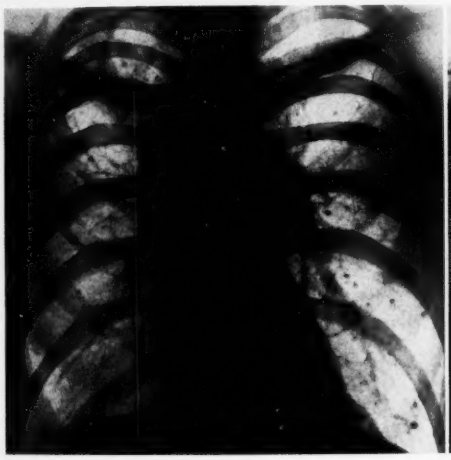

Fig. 9. Healed miliary tuberculosis.

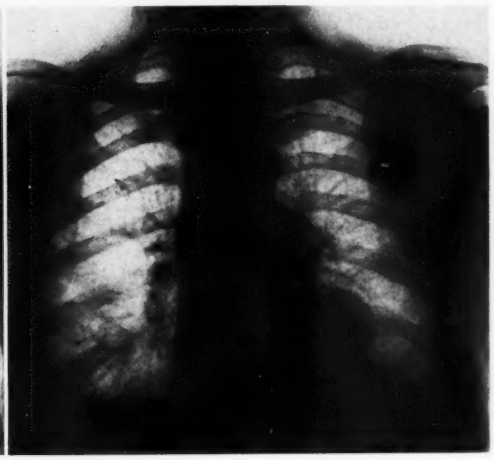

Fig. 10. Metastatic carcinoma. Primary lesion in right breast.

diagnosis. Repeated or serial roentgenograms for the purpose of studying the morphological changes are extremely important. I have recently seen a case of this type of pulmonary tuberculosis, through the courtesy of Dr. S. Bruck, in a young woman whose pulmonary fields presented these round foci, which had at first been diagnosed as tumor metastases (Fig. 1).

The exudative type of pulmonary tuberculosis first manifests itself as a cluster of minute, soft infiltrations at the periphery of the lung in the apical or sub-apical region. No other condition with the exception of actinomycosis, which is very rare, produces a similar picture (Sante). These soft infiltrations may coalesce and form an irregularly shaped consolidation or may calcify, producing clean-cut discrete shadows (Fig. 2).

In miliary tuberculosis of the lungs we have a uniform pinhead-sized infiltration extending from the apex to the base, and with the exception of healed miliary tuber-

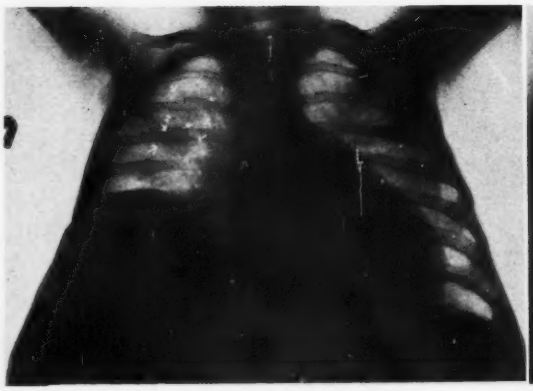

Fig. 11. Metastatic sarcoma. Primary lesion in right adrenal.

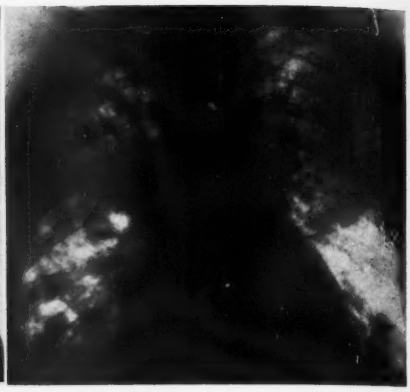

Fig. 12. Metastatic malignancy (?) Clinical diagnosis, polycythemia vera. No primary lesion found; no autopsy.

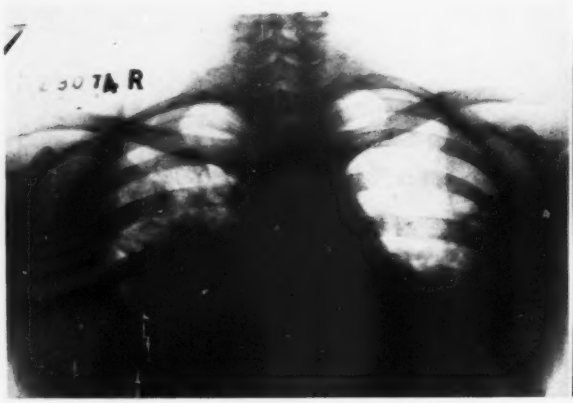

Fig. 13. Hodgkin's disease; pulmonary involvement, the nodules showing confluence.

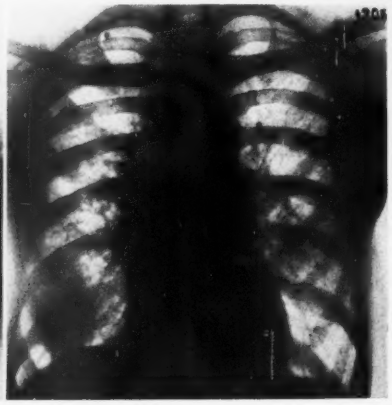

Fig. 14. Pulmonary syphilis (gumma) ? Patient greatly improved under antisyphilitic treatment.

culosis, the lesions are soft in consistency. In serial roentgenograms, they will be seen to increase in number and size, although they never attain the size of the nodules observed in bronchopneumonia and rarely coalesce. It is well to remember that in these patients there is little, if any, evidence of previous tuberculosis of the lung. This acute type very often simulates miliary bronchopneumonia and septic pneumonia, both clinically and roentgenologically, the symptoms being very severe in each instance. However, miliary bronchopneumonia and embolic pneumonia are rare and roentgenographically the foci in miliary bronchopneumonia appear larger and acquire a peribronchial distribution, involving the lower two-thirds of the lungs. In emobolic pneumonia the infiltrations are rather blotchy in appearance and poorly defined. They may be scattered throughout the lungs, but the lower lobes and the hilum regions are chiefly involved. The condition is usually a part of a generalized infection and a blood culture will, of course, aid in the diagnosis. Serial exposures will show, if the patient survives, resorption of the lesions.

Again, the picture of miliary tuberculosis, particularly the chronic form, is also suggestive of miliary carcinoma and pneumoconiosis in its second stage. There are,

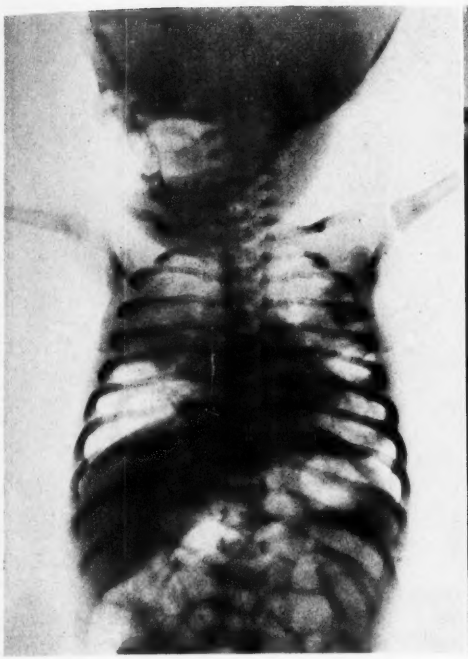

Fig. 15. Congenital cysts. Some of the cysts contain fluid, some air.

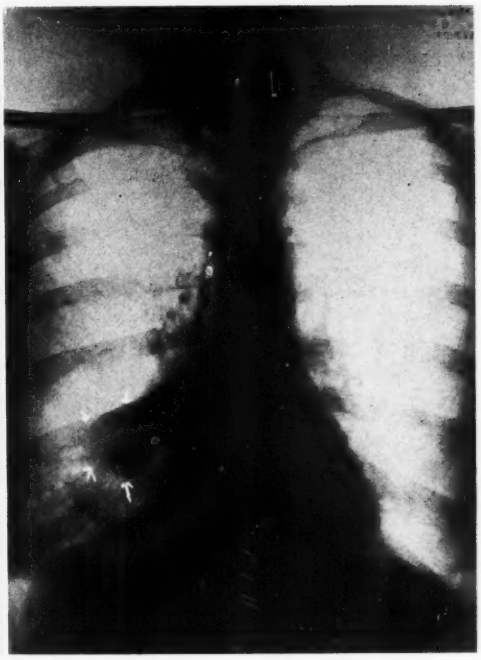

Fig. 16. Lobular atelectasis due to a benign papilloma arising from the right lower bronchus.

however, some variations in size, consistency, and distribution of the nodular shadows which will aid in differentiating them (Figs. 3, 4, and 5).

In the miliary type of metastasis, a very rare condition, both lungs are studded with discrete opacities; however, the upper thirds usually show comparative freedom from these deposits. The infiltrations are larger and irregular, and, with the exception of the calcific-like metastases occurring in some forms of osteogenic sarcoma, never calcify. The history of a previously existing malignant growth will aid in differentiating this condition (Fig. 6).

The second stage of pneumoconiosis presents a diffuse, fine mottling throughout both lungs due to very small fibrotic nodules. These nodules vary in size from a pinhead to a pea, and usually start, first, on the right side near the root of the lung, and later acquire a more uniform distribution. The history of occupational exposure to dust and the mild clinical evidence of a process as extensive as the roentgenogram would indicate, should determine the differentiation between this condition and the diseases presenting a similar appearance (Figs. 7 and 8).

Occasionally one encounters a roentgenogram showing a symmetrical distribution of minute calcified deposits. These shot-like deposits remain stationary in serial roentgenograms, and, according to Opie, may represent healed miliary tuberculosis (Fig. 9).

Secondary carcinoma and sarcoma usually record themselves in the lung structure by the presence of round plaques of variable size with no inflammatory reaction of the surrounding tissue. These opacities are usually more numerous in the lower lobes and rarely, if ever, involve the apices. The infiltrations of sarcomatous nature may be circular, sharply outlined, and larger than the ordinary carcinomatous metastases, which are small and somewhat irregular (Sante). However, it is not always pos-

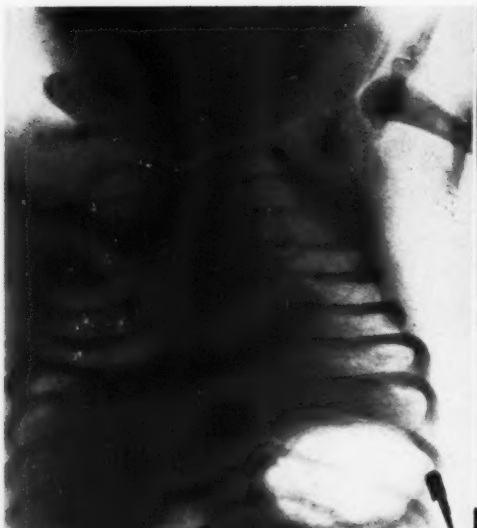

Fig. 17. Anectasia or failure of complete lung expansion in a newborn.

Fig. 17-*A*. Same case as shown in Fig. 17. Disappearance of the anectatic areas with complete lung expansion.

sible to differentiate between the two on the roentgenogram; nor is the differential diagnosis between metastatic malignancy and similar opacities produced by inflammatory and benign conditions simple from the roentgenologic findings alone. The clinical aspects of the case and the serial roentgen examination at intervals are frequently necessary for a clear differentiation (Figs. 10, 11, and 12).

In rare cases of leukemia and Hodgkin's disease, multiple small shadows may be seen throughout the lungs resembling miliary bronchopneumonia and miliary tuberculosis. The associated mediastinal adenopathy, clinical and blood findings suggest the nature of the lesions. Saupe has recently drawn attention to the more common occurrence of this type of Hodgkin's disease, and states that the pulmonary foci may develop before involvement of the gland structure. In cases in which there is no associated mediastinal tumor the nature of these foci offers a difficult problem. It is well to remember that a test treatment may be of aid in the differential diagnosis, since lymphomatous masses react very favorably to radiation (Fig. 13).

The lungs in Niemann-Pick disease may rarely show small shadows resembling generalized bronchopneumonia. The presence of such infiltrations in infants having splenohepatomegaly should suggest the possibility that these may be local manifestations of a general disorder in lipoid metabolism.

Discrete pulmonary manifestations in syphilis are not at all common. The tertiary stage may occasionally become roentgenologically demonstrable by the appearance of ill-defined and irregularly round foci. These shadows are usually found in the lower portion of the lungs in close relation to the hilum. They are often connected with fibrous strands extending into the adjacent lung structure and rarely liquefy to form cavities; more frequently they become converted into fibrous tissue. Calcification is absent. Syphilis of the lungs records a picture with no characteristics to stamp its true nature. Some observers believe that the lung structure is relatively, if not entirely, immune from

syphilitic infection. Sante claims that he has never observed an authentic case of lung syphilis, nor does he know of any proven case recorded. However, the Wassermann test and the finding of the infection in other organs may help in the diagnosis (Fig. 14).

Cystic lung disease is not of common occurrence. It may be congenital or due to parasitic infestation, and may occur as a single lesion or present multiple cysts scattered throughout one or both lungs.[1]

Cysts of congenital origin are often an accidental finding, though they may present clinical symptoms. They appear as small, round, sharply delineated shadows of homogeneous density without any surrounding lung reaction (unless they rupture or become infected), or as thin pocketed cavities suggesting localized pneumothoraces. The persistence of these shadows without change and the paucity of the clinical symptoms are factors to be considered in the differential diagnosis (Fig. 15).

Cysts due to parasitic infection include the echinococcus and cysticercus, the presence of which is very often marked by clinical manifestations. The findings in the roentgenogram will depend on whether the cyst has ruptured or is closed. In the former type the cystic lesion may be obscured by the inflammatory reaction, which closely resembles pulmonary abscess; in the latter, the shadows are fairly characteristic, being circular, sharply circumscribed, and of homogeneous content, with the exception of the opacities in cysticercosis, which may have a central pea-sized nucleus (Lachmann). To differentiate the closed type from metastatic tumor, the age of the patient as well as the prolonged course with relatively slight disturbance of general health may be of aid in establishing a diagnosis. Serologic study will help rule out syphilis.

Lobular atelectasis is a secondary manifestation resulting from bronchiolar occlusion or stenosis. The appearance on the film is that of small, irregular, dense areas, very often resembling lesions of other etiology. The roentgenologic diagnosis may offer considerable difficulty, and a careful consideration of the clinical history and other methods of examination are necessary to supplement the information given by the x-ray (Fig. 16). It is well to bear in mind that the small, irregular, patchy shadows noted on chest films of newborn are due to anectasia or failure of complete lung expansion, and that repeated roentgen study will reveal the nature of these opacities (Figs. 17 and 17-*A*).

[1] Dermoid cyst and teratoma are not considered in this presentation as they occur most frequently within the mediastinum and displace rather than invade the lung tissue.

CONCLUSIONS

In conclusion, it may be briefly stated that—

1. The roentgenologic examination affords the best means of detecting these lesions.

2. The discrete shadows cast by the many pathologic processes present roentgenologic appearances that closely resemble each other.

3. A definite knowledge of the history, clinical manifestations, and laboratory studies are essential for a differential diagnosis.

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METHODS OF ENHANCING ROENTGEN-RAY ACTION

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THE problem in the treatment of malignant disease by means of radiation is at present directed along two lines: (1) In which the malignant tissue is made more sensitive to the action of radiation; (2) in which radiation is made more lethal to the malignant cells.

We have used electric currents of high frequency, 30 to 50 million cycles per second, with a wave length of from six to ten meters, in the treatment of Flexner-Jobling rat tumors[1] and, after having determined the action and the result of treatment with this modality, have combined it with roentgen therapy to determine whether the action of the roentgen ray is modified by the giving of high frequency before, during, or, after roentgen therapy. We also have studied the action on these tumor cells of high frequency currents and roentgen rays, when metallic radiators were placed within the tumor tissue.

VARYING TISSUE SENSITIVITY TO ROENTGEN RAY

A great deal of work has been done upon the methods of varying tissue sensitivity to roentgen ray by interference with the blood supply of various tissues (24, 25, 11, 12, 53). While the roentgen-ray reaction is diminished following the occlusion of blood vessels as demonstrated by the above workers, active hyperemia induced by thermal changes, ultra-violet ray, irritating and toxic substances, increases the reaction to roentgen ray (23, 26, 19, 20, 44, 7, 8, 31, 33, 42, 18, 32, 2).

If we could cause a selective action, affecting only the malignant cells, and but very little of the surrounding tissues, then these various methods of making tissues more sensitive to the action of roentgen ray might be of some value. If the malignancy is in the skin, the various uses of infra-red, hot water bags, long wave diathermy, ultra-violet ray, and skin irritants might be of some value in causing greater reaction to roentgen ray. However, when the tumor is below the surface, an effort must be made to get less skin reaction and more depth reaction in the tumor cells. With this thought in mind, therefore, we investigated the effects of radiothermy upon tumor growth, for we know that these short radio waves produce more heat at a depth than at the surface.

FEVER AND TUMOR REGRESSION

There is a great deal of controversy upon the value of fever in the destruction of cancerous tissue. The beneficial result obtained by means of Coley's toxins (toxin produced by erysipelas and prodigiosus bacteria) is said to be due to the fever which is produced by them (5). The greater the fever, the greater the number of cases of regression. We have noticed several cases of highly malignant and fast-growing tumors disappear with an attack of erysipelas, and this is likely to be especially true in the case of old people.

Rohdenburg (45), in a study of regression of human cancer, found that spontaneous cures have followed acute febrile attacks, or incomplete surgical removal of the tumor, and, occasionally, profound metabolic changes, such as extreme cachexia, artificial menopause, or puerperium. Cases of regression of human cancer have occurred after attacks of malaria, typhoid fever, and tuberculosis (6).

Exactly how fever works is not known; whether fever is a mere expression of a more basic physico-chemical change going on in the cells, or whether the fever itself is the important factor is still in the process of investigation. Artificial fever produced by high frequency electric currents has been studied in many diseases. Its study in

[1] We are greatly indebted to Kanematsu Sugiura, M.D., of Memorial Hospital, New York City, from whom we obtained the Flexner-Jobling tumor.

syphilis has been undertaken by many investigators (46, 4, 28, 41). Bishop, Horton, and Warren (3) report its use in gonococcus conditions, local and generalized, multiple scleroses, and encephalitis, acute and chronic. Tenney (50) studied its action in arthritis, bursitis, myositis, and neuritis, and its application in Raynaud's disease, thrombo-angiitis, and arterial sclerosis.

From these numerous studies it has been found that as a result of heat there is at first a systolic rise and a diastolic drop in the blood pressure; later on in the series of treatments, both systolic and diastolic pressure drop and stay down. There is an increase in heart rate and a dilatation of blood vessels. Concentration phenomena occur, such as a rise in red and white blood cells and in hemoglobin, an increase in nonprotein nitrogen, in blood uric acid, blood chlorides and calcium, and a decrease in the CO_2 capacity of the plasma (41). Hinsie and Blalock (22) describe the increase in leukocytes. Tenney (50) states that there is an increase in blood platelets and an increase in the number and size of the capillaries of the nail-bed; the skin wheal due to histamine is larger after heat therapy than before. The viscosity of the blood increases unless plenty of fluids are given during treatment.

In tumors, this dilatation of blood vessels, increase in viscosity, and accompanying thrombosis may have something to do with the beginning of tumor regression, the increase in white blood cells, and especially the lymphocytes, which also contribute to the regression (10, 40).

DeCourcy (6) believes spontaneous regression of cancer is due to dilatation of blood vessels, hemorrhage, thrombosis, necrosis, and lymphatic infiltration in the tumor. Immunological reaction produced by protein absorption from this mass completes the regression of the local tumor and distal metastases. This disturbance in the circulation of some mouse and rat tumors by the injection of bacterial toxins producing the Swartzman reaction is said to be the cause of the tumor regressing (9). It is probably also the cause of regression of tumors in cases in which only an incomplete surgical removal is done, or the taking of a biopsy, and in such cases as those in which rattlesnake venom is given.

As a result of the numerous instances in which fever was found to be associated with the regression of tumors, a great deal of experimental work has been done, and is still being done, with conflicting reports, on the application of heat, especially that produced by high frequency currents, on the regression of plant, experimental animal, and human tumors.

Gosset, Gutmann, Lakhovsky, and Magrou (17), who were the first to work on the effects of high frequency electro-magnetic radiation produced by a vacuum tube oscillator, in 1924, found that in three geranium plants bearing tumors produced by *Bacterium tumefaciens*, the tumors disappeared at the frequency of 150,000,000 cycles per second (wave length of 2 meters). One plant was given two exposures of three hours each on consecutive days, one plant was given three, and one plant, eleven such exposures. After sixteen days from the first exposure, the tumors, after growing in the interval, began suddenly to necrose. In fifteen days the tumors could be detached by slight traction.

Working only with heat as produced by an electrical frequency, Schereschewsky (47), by the application of varnish-covered copper electrodes through which a frequency of 90 to 100 million cycles per second (wave length, 3 to 3.3 meters) was passed directly to the tumors, with two- to three-minute exposures and a milliamperage of 200 to 300, got 60 to 75 per cent tumor regression in mice when the tumors were below 15 to 20 mm. in diameter. The mouse sarcoma, C.R. 180, was used. The same percentage of recoveries occurred in the rat sarcoma in tumors below 30 to 50 mm. in length. He obtained recoveries in Rous fowl sarcoma. The temperature of the tumor went up to 48 to 49.6 degrees C. in from 1.5 to 2 minutes. He believes that the effect is solely due to heat, for when the tumors to be grafted were placed in Locke's solution at 48 to 49 degrees for

three minutes, this prevented growth when the transplants were made. Also, if the tumors were placed between two hollow copper electrodes through which water heated to 48 to 49 degrees C. circulated, the tumor disappeared.

Reiter (43) found that the most effective wave length in the treatment of Flexner-Jobling tumors was between three and four meters, *i.e.*, a frequency of 75 to 100 million cycles per second. His study included waves between three to seventeen meters. He found that between three and four meters the change produced by the dielectric loss is a dilatation of the blood vessels, edema, and necrosis, *i.e.*, the changes are essentially inflammatory. The rats were exposed for five two-minute periods at intervals of one minute. Eighty per cent of the tumors disappeared by this method.

He thought that the temperature effects could be excluded, and that the main effect was a marked suppression of the anærobic fermentation of sugar, rising as high as from 80 to 90 per cent with a wave length of 3.4. Human material showed this effect with a wave length of 3.65 meters. He found that the roentgen ray showed no effect on the anærobic fermentation with as high as 5,000 r units; above this the effects were the same as short radio wave.

Fuke (13, 14) found that the Flexner-Jobling carcinoma disappeared with a 30-minute treatment by means of diathermy heat, with 250 milliamperes. Sometimes a second application was necessary. When he used 300 milliamperes the animal died. This, he thought, was due to a reduction in the blood sugar, as well as local inflammatory changes in the tumor. Reduction of blood sugar was due to accelerated glycolosis.

Ludwig and Von Ries (30) found that high frequency given to both plant seedlings and mouse carcinoma, in daily treatments of three seconds each, inhibited but did not totally destroy growth.

According to Knopfmacher (29), high frequency restores the power of the patient's serum to digest cancer cells. Freund's theory is that the serum of the cancer patient will not destroy cancer cells, whereas normal serum will.

Some investigators believe that heat has no effect whatever on the tumors.

Woglum (51), causing fever in rats and mice as high as 42 C., for a total number of 31 to 340 hours, found no effects upon the tumors. So also did Kamekura (27), who kept tumor-bearing mice for 20-minute periods two to three times weekly in incubators at 42 degrees C. (107.6° F.), obtain negative results. However, Schereschewsky (47) states that his results were obtained with tumor temperature of 48 degrees C., the temperature of the animal itself remaining near normal. There may, of course, be some properties of the high frequency current independent of heat.

Mellon, Szymanowski, and Hicks (39) found that, using a frequency of 158,000,000 cycles per second, the activity of the diphtheria toxin was reduced with temperatures as low as 15 degrees C.

McKinley (34) found that, on exposing the whole vertebral column of the frog to 90 million cycles per second, an immediate violent muscular contraction of the hind legs occurred. With the application of external heat to the vertebral column this did not take place. Nor are all tissues in the same organism affected equally. Schliephake (48) found the heating rate of brain tissue to be high. Headlee and Burdette (21) found cholesterol, present in great abundance in nervous tissue, to have the highest heating rate, when compared to many other organic compounds.

Even in the inorganic field, according to McLennan and Burton (38), the heating effect depends upon the kind of substance in solution and its concentration. In solutions of lower concentration the maximum heating effect is observed when lower frequencies are used, and at higher concentrations the maximum heating effect is observed with higher frequencies.

According to McKinley (35, 36, 37), the high frequency action may be different at different phases in the development of an organism. In working with insects in which the nervous system was more highly

organized in the adult than in the larval form, the time of the lethal exposure was six times longer in the larval form. Where little difference existed in the nervous system between adult and nymph, the lethal dose was the same.

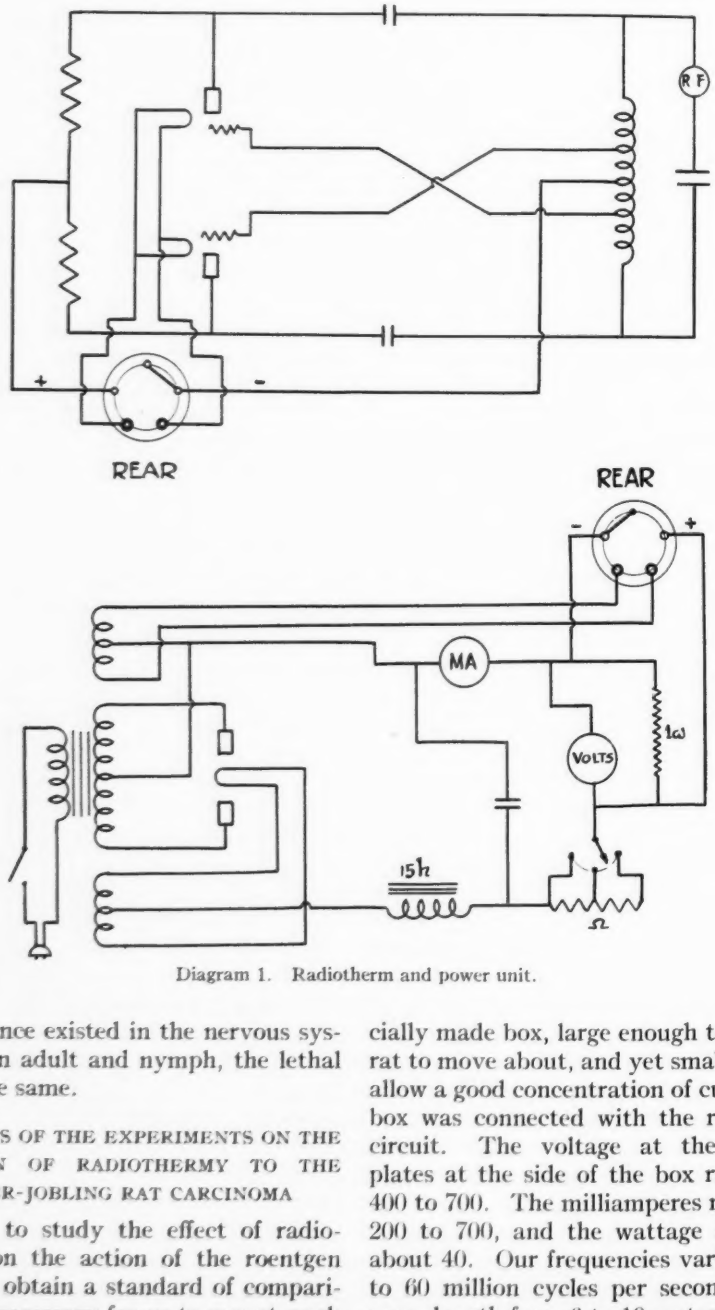

Diagram 1. Radiotherm and power unit.

THE RESULTS OF THE EXPERIMENTS ON THE APPLICATION OF RADIOTHERMY TO THE FLEXNER-JOBLING RAT CARCINOMA

In order to study the effect of radiothermy upon the action of the roentgen ray, and to obtain a standard of comparison, it was necessary for us to repeat work upon which there remained some controversy, namely, the effects of radiothermy alone on tumor growth. We had a specially made box, large enough to allow the rat to move about, and yet small enough to allow a good concentration of current. The box was connected with the radiothermy circuit. The voltage at the condenser plates at the side of the box ranged from 400 to 700. The milliamperes ranged from 200 to 700, and the wattage output was about 40. Our frequencies varied from 30 to 60 million cycles per second, and the wave length from 6 to 10 meters.

In order to obtain the above factors at the condenser plates, we had several tube machines made under our direction by Marsh and Maxham, engineers of Montvale, N. J., and toward the latter part of the work, in order that a stronger voltage, wattage, and milliamperage might be tried, we used a Lepel short wave thermy, which wave length ranged between 6 and 9, voltage 5,000, milliamperes, 2,000 plus, and wattage, 140. Our first machines were thermionic oscillators, whereas Lepel's is a spark discharge oscillator. Diagrams 1 and 2 give the outline of the radiothermy set-up.

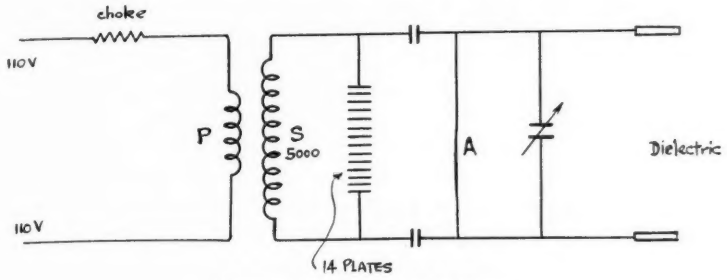

Diagram 2. Lepel's Radiothermy.

The animals received from one to 25 treatments, averaging eight; the treatments were given daily, and the temperatures ranged from 97 to 108.6° F. The temperature usually rose to 103 degrees about one-half hour after the beginning of treatment, which lasted from one to two hours. Occasionally, the temperature continued to rise until the end of the treatment, but more frequently it would start to fall about the end of the first hour. In the majority of cases by the end of the first hour after treatment was completed, the temperature had returned to normal. The animals underwent a great deal of shock while in the treatment box; they became hot and had nosebleeds. The ears became red and the testicles reached two to three times their usual size. The animals sweated a great deal and became very restless. However, as soon as the treatment was completed, they would eat, and soon appeared normal.

Our opinion is that in the animals treated, the tumors grew more slowly, ulcerated later, and grew to a bigger size before ulceration. In order that we might not be misled by the possibility that the tumor would disappear anyway without treatment, we usually took the largest tumors for the experimental animals, and used the animals with the smaller tumors for the controls. We rarely started treatment unless the tumor was 1 cm. in diameter, sometimes waiting three weeks before doing so. If we disregard all tumors except those which had reached the dimensions of 1 cm. in diameter, then only 9 per cent of the tumors which were not treated disappeared, whereas 21.7 per cent of the tumors which were treated disappeared (See Table I). We had several large ulcerating tumors, one tumor being 2 by 2.5 cm., and the other 1.2 by 1.2 cm., which healed after treatment.

It seems to us that the increase in temperature, with the sweating accompanying it, made the tumor smaller, probably from dehydration. The ulcers appeared dryer, and quite often would form scabs. Probably this water absorption was a factor which prevented rapid growth. As we know, the greater the water concentration in the tumor, the faster the rate of growth. While we admit that there is a slight advantage, we doubt very much that this method of treatment in itself, and alone, is worth while, and surely it is not practical, and cannot approach the efficacy of the other methods of treating cancer. However, when the radiothermy is applied locally to the tumor, more heat can be

given without killing the animal, and the results are better, according to Schereschewsky, *et al.* (47).

THE RESULTS OF THE EXPERIMENT ON THE APPLICATION OF ROENTGEN THERAPY TO THE FLEXNER-JOBLING RAT CARCINOMA

Before we could evaluate the action of radiothermy and roentgen ray given simultaneously to the Flexner-Jobling rat tumor, it was also necessary to determine the action of roentgen therapy alone on this tumor. We made provisions to apply roentgen ray to the whole animal through the top of the radiothermy box. The animals usually received about 400 r to the tumors. This amounted to one-half or one skin erythema dose, depending upon whether or not filters were used.

We tried the effects of roentgen ray with no filters. Also, we used 0.25 mm. copper and 3 mm. aluminum; we used 0.8 mm. copper and 3 mm. aluminum on other cases. We used 100 kilovolts with no filter, 150 kilovolts with 0.25 mm. copper and 3 mm. aluminum, and 180 kilovolts with 0.8 mm. copper and 3 mm. aluminum. We used 5 milliamperes, distance 30 cm. from target to tumor.

Sugiura and Benedict (49), working with this Flexner-Jobling tumor and the amount of gamma rays measured in skin erythema doses, found that no tumor regressed with less than 1.5 skin erythema dose, and that one-half of the tumors regressed with two to three skin erythema doses. With more than three skin erythema doses, regression occurred in 90 per cent of the cases in which tumors were not more than 2 cm. in diameter. Tumors from 2.4 to 3.3 cm. in diameter were seldom destroyed with doses as large as six skin erythema doses.

Since our tumors were usually treated when they were about 1.5 cm. in diameter, and since they never received more than one roentgen-ray skin erythema dose, our percentage of cures was not as high as that obtained by Sugiura.

Of course, there was some question as to whether the giving of roentgen ray to the whole organism instead of to the tumor alone might not produce some general or

TABLE I.—RESULTS OF INVESTIGATION OF EFFECTS OF FEVER PRODUCED BY SHORT RADIOTHERMY ON THE FLEXNER-JOBLING RAT CARCINOMA

Number of series	14
Number of animals transplanted	137
Number of positive transplants	81
Percentage of positive transplants ranged from 13 to 100, average was	58.4

	Controls (44)	*Experimental animals* (37)
Tumors cured		
Number of tumors cured entirely, and percentage[2]	17 (38.6%)	13 (35%)
Number of tumors disappearing, but animal died before cure	0	0
Number of tumors above 1 cm. cured entirely, and percentage	4 (9%)	8 (21.7%)
Largest tumor cured	$1\frac{1}{4} \times 1\frac{1}{4}$ cm.	$2\frac{1}{4} \times 2\frac{1}{2}$ cm.
Age of largest tumor cured	8 wks.	18 wks.
Smallest tumor cured	$\frac{1}{8} \times \frac{1}{8}$ cm.	$\frac{1}{4} \times \frac{1}{4}$ cm.
Average size of tumors cured	$\frac{2}{3} \times \frac{2}{3}$ cm.	$1 \times 1\frac{1}{2}$ cm.
Average age of tumors cured	4.4 wks.	7.6 wks.
Tumors ulcerating[3]	27	24
Size reached before ulceration occurred:		
Greatest size	4×4 cm.	$4\frac{1}{2} \times 5$ cm.
Smallest size	$\frac{3}{4} \times \frac{3}{4}$ cm.	$1\frac{1}{2} \times 1\frac{1}{2}$ cm.
Average size	$1\frac{1}{2} \times 1\frac{3}{4}$ cm.	$2\frac{1}{2} \times 2\frac{1}{2}$ cm.
Age of tumor before ulceration occurred:		
Greatest age	10 wks.	$9\frac{1}{2}$ wks.
Shortest age	$2\frac{1}{2}$ wks.	$3\frac{1}{2}$ wks.
Average age	4 wks.	5 wks.
Number of tumors healing after ulceration	0	2 $\left\{\begin{matrix} 2 \times 2\frac{1}{2} \\ 1\frac{1}{8} \times 1\frac{1}{2} \end{matrix}\right.$

[2] Experiments were started on tumors at the age of two weeks. According to Sugiura (49), 20 per cent of tumors disappear after the age of two weeks without treatment.

[3] This depends a great deal on depth of transplantation. We tried to keep ours uniform.

immunological reaction to cause the disappearance of the local tumor. Although the number of tumors which disappeared with roentgen ray did not seem to be any greater than the number that disappeared without any type of treatment, it must be remembered that if tumors above one centimeter only are considered, then the number that disappeared with roentgen ray alone was 16.6 per cent, with diathermy alone, 21.6 per cent, and with diathermy and roentgen ray together, 38.4 per cent (See Table II).

The giving of roentgen ray alone did not raise the temperature of the animals, except in an occasional case, and then the temperature was never more than one or two degrees above the temperature before treatment. Occasionally the giving of roentgen ray was accompanied by a decrease in temperature of one or two degrees, especially if the temperature at the beginning of treatment was one or two degrees above normal.

THE ACTION OF ROENTGEN RAY AND RADIOTHERMY GIVEN SIMULTANEOUSLY

When the above roentgen-ray treatment was given before or after the usual radiothermy treatment, there did not appear to be any unusual changes in the general condition of the animals or in the number of tumor regressions other than those observed when radiothermy alone was given.

However, when roentgen-ray therapy was given simultaneously with radiothermy, very unusual reactions occurred. The first thing noticed was that the animals' temperatures went up on the average of two or three degrees higher than they did with radiothermy alone, and whereas the animals could always be kept under radiothermy two or more hours at a time, when roentgen therapy was given at the same time the animals began to fight and run mad in the box ten or fifteen minutes after the starting of the treatment. Of those that were given the full twenty minutes of roentgen-ray treatment, 23.05 per cent

TABLE II.—RESULTS OF THE TREATMENT OF FLEXNER-JOBLING RAT CARCINOMA WITH RADIOTHERMY AND ROENTGEN RAY COMBINED

Number of series	12
Number of animals transplanted	129
Number of positive transplants	78
Percentage of positive transplants ranged from 0 to 100, average	60.4

	Controls (X-ray alone) (36)	*Experimental animals* (39)
Tumors cured		
Number of tumors cured entirely and percentage	9 (25%)	18 (46.1%)
Number of tumors disappearing, but animal died before cure	3 (8.3%)	9 (23.05%)
Number of tumors above 1 cm. cured entirely	6 (16.6%)	15 (38.4%)
Largest tumor cured	2 × 2 cm.	1½ × 2 cm.
Age of largest tumor cured	9 wks.	5½ wks.
Smallest tumor cured	1½ × 1½ cm.	½ × ½ cm.
Age of smallest tumor cured	1½ wks.	2 wks.
Average size of tumors cured	1½ × 1½ cm.	1½ × 1¾ cm.
Average age of tumors cured	4.7 wks.	4.5 wks.
Tumors ulcerating		
Number	24	12
Size reached before ulceration		
Greatest size	3½ × 3½ cm.	4 × 5 cm.
Smallest size	2 × 2 cm.	2 × 2½ cm.
Average size	2 × 3 cm.	3 × 3½ cm.
Age of tumor before ulceration		
Greatest age	6 wks.	7 wks.
Shortest age	3 wks.	5 wks.
Average age	4.5 wks.	4.5 wks.
Number of tumors healing after ulceration occurred	0	0

died. Some died before the treatment was ended, and the others, one, two, or three days later.

The temperatures usually started to come down in the second hour of treatment when radiothermy alone was given; with the combination of radiothermy and roentgen ray, the temperature continued to rise and the number of animals that died from the treatment increased. Although the mortality is greater, the number of tumors that disappeared with radiothermy and roentgen ray given together is greater than with any other treatment we have used, amounting to 46.1 per cent of the animals treated.

The question arises, Does roentgen ray enhance radiothermic action in causing this greater rise in temperature, thus causing more tumors to disappear, or does radiothermy enhance roentgen-ray action by causing greater ionization, and in this way causing greater biological reaction and tumor regression? Or is there merely a summation effect? This opened up a new field for our study on the action of roentgen ray in the radiothermic field, and the action of radiothermy in the roentgen-ray field. We thought that if these various factors could be determined physically, the biologic actions of both radiothermy and roentgen ray might be better understood.

The first experiment undertaken was to determine if there was a greater deposit of silver on a photographic film when radiothermy and roentgen ray were given together than the sum of both given at two different times. Secondly, by using saline solution, in which were immersed a copper and a tin electrode connected to a milliameter, to determine if there were a greater flow through the circuit when radiothermy and roentgen ray were given together than the sum of the two given separately. Thirdly, by means of an ionization chamber, to determine if the number of r per minute was greater when roentgen ray and radiothermy were given together than when roentgen ray was given alone.

Film Test.—It is known that a latent image will be formed by heat on a photographic film. It is also known that radiothermy causes heat. The alternating charging of the condenser plates causes a dielectric stress in the air between them, and in doing so some energy is lost. While condensers will give back to the circuit almost all the energy put into them, some energy is lost. The amount lost depends upon the capacity of the condensers, the greater the capacity the less the loss; depends upon the frequency with which they are charged and discharged, the greater the frequency the less the loss; also, it depends upon the substances between the plates, *i.e.*, the type of dielectric. There is a greater loss with solid dielectric. In other words, when large animals are placed in the box, the more solid the dielectric becomes, the harder it will be for the condenser plates to cause a stress upon the animal molecules and, therefore, the more energy expended, and the more heat formed. This is what is known as heat formed because of dielectric loss. However, with the photographic film, the dielectric loss is so small, so little heat is formed, that it is apparently insufficient to cause a latent image, as is shown by the following test.

If a small piece of process film is cut in two, and one part only is placed in the radiothermy box for twenty minutes, both parts being kept in total darkness, and the two parts are then developed together for five minutes, there will be no deposit of silver on either film. If radiothermy is given to a similar piece of film for twenty minutes, and then roentgen ray is given afterward for one minute, the amount of silver deposited after the film is developed is appreciably less than when radiothermy and roentgen ray are given together for one minute only. Thus it seems that radiothermy by its dielectric ionic stress, or by its trying to pull the electrons more to the periphery of the atom, or if they are loose to pull them away from the atom, merely helps the roentgen ray to ionize these atoms, and if by chance there are some electrons which roentgen ray alone could just bring to the parting point, this radiothermic stress is enough to give the final

push or pull. This film test shows that roentgen-ray action is enhanced in a radiothermic field.

The second experiment, in which we had copper and tin electrodes connected with a milliameter and the ends immersed in saline solution, we used for the following reasons: We know that the heat caused in an animal by means of a condenser is equal to the displacement current caused in the animal, times the resistance of the animal (Wattage = I^2R). We were anxious to find out whether roentgen ray added to radiothermy caused an increase in the amount of displacement current, and in this way produced a greater amount of heat. The amount of current caused by two dissimilar electrodes immersed in saline was registered on the milliameter. The milliameter had chokes on each side so that it would not be affected by the radiothermy and was covered by lead so that it would not be affected by the roentgen ray. The amount of current in the milliameter was recorded when roentgen ray and radiothermy were given separately and when given together. There was an increase of a few milliamperes above the normal when radiothermy was given alone; about the same amount when roentgen ray was given alone. When radiothermy and roentgen ray were given simultaneously, there was sometimes as much as a 50 per cent increase over that of either radiothermy or roentgen ray alone. The temperature of the solution was kept the same, so that the increase in resistance to the current due to heat would not have to be considered.

This experiment shows that roentgen ray, by means of ionization, increases the displacement current in the animals caused by the condensers. In this way one can explain the cause of greater temperatures when roentgen ray is added to radiothermic action.

In the third series of experiments, in which an ionization chamber was placed in the box, we found that radiothermy alone, given for one-half hour or more, caused no loss in the charge in the ionization chamber. The experiments when roentgen ray alone was given, and when radiothermy and roentgen ray together were given, have not been very satisfactory. We usually get one or two more r per minute when radiothermy and roentgen ray are given together than when roentgen ray is given alone. Occasionally we have been able to get as much as twice the amount of r units per minute when roentgen ray is given with radiothermy than when roentgen ray is given alone, but we have not been able to do this consistently. Therefore, this experiment has not helped us very much in determining the mode of action of radiothermy in a roentgen-ray field.

METHODS OF INCREASING RADIOTHERMIC AND ROENTGEN-RAY ACTION ON FLEXNER-JOBLING RAT CARCINOMA BY MEANS OF METALLIC RADIATORS

Radiothermy.—When small steel needles are placed in the periphery or growing edge of a tumor, and the animal is then placed in the radiothermy box, these steel needles heat up much faster and hotter than the tissue, the result being that there is formed a zone of dying tissue about the needles, about two millimeters in thickness. However, if this needle is placed within the necrotic center of the tumor, no reaction is caused. Further from the zone of necrosis areas of hemorrhage are seen. In other words, here is a method of artificially producing the same biologic effect as radium. The tumor at first swells, looks edematous, and seems to grow faster than the control on the other side of the animal, but this is only apparent, because in several weeks the control reaches a much greater size. Sometimes the tumor with the needles ulcerates because of the edema and swelling, but this soon dries to a hard scab, and later the tumor disappears while the control grows to ulcerate and kill the animal. Many animals, however, have died of the cancer, which can probably be explained by the inability to accurately place the needles so that all parts of the growing tumor cells have been reached. We have not, however, used a sufficient number of animals to warrant a conclusion as to the value of this treatment.

Roentgen Ray.—The use of metals as secondary radiators of roentgen ray has been tried before (1, 16, 15). Wood (52), found that colloidal lead, more than any other colloidal heavy metal, when combined with radiation, had a beneficial effect upon experimental tumors. It would be interesting to note what effect diathermy had on experimental animals in which was injected colloidal lead, either locally or intravenously.

By means of steel needles placed within the growing periphery of the tumor we have been able to give roentgen ray of a short wave length, therefore causing less damage to the skin and obtaining a greater depth dose than would have been possible with a longer wave length. The steel radiators change the short waves to long waves, thus causing more damage to the tumor tissue itself. This type of treatment also caused edema in the beginning, and slight ulceration, but the tumor grew much slower than the control on the other side. Likewise, in these animals that were given roentgen ray, there appeared a zone of necrosis about the needles.

Again, the number of experiments we have done has been too few, and we cannot give a definite report at this time as to its value.

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CASE REPORTS

PLASMA-CELL MYELOMA OF THE RIGHT ILIUM ROENTGENOLOGICALLY MISTAKEN FOR GIANT-CELL TUMOR

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This case is reported because of its unusual diagnostic features. The patient, a woman aged 49 years, was referred to the Orthopedic Service of the Wisconsin General Hospital on May 16, 1935, because of pain in the right hip. She had slipped and fallen on the hip in September, 1934, but was able to get up and walk with moderate pain. Hot pads were used which gave some relief. Two months elapsed without much change in her condition. She consulted first a chiropractor who treated her, and then saw an osteopath in March, 1935, who "set" the hip. No cast was applied. Walking remained more or less impaired and painful. Since no improvement in her condition occurred she finally consulted a physician who referred her to the Wisconsin General Hospital.

Her general physical examination, laboratory findings, and gynecological examination were negative (no Bence-Jones in urine). She was unable to walk or stand without the aid of crutches. There was loss of normal contour along the right iliac crest because of a tumor mass extending along the lateral aspect. The tumor was fixed to the underlying pelvis. The skin showed brownish pigmentation, apparently due to previous hot applications.

The roentgenograms of the pelvis showed a multiloculated lesion in the right ilium, which, in our opinion, had the appearance of a giant-cell tumor (Fig. 1). The films were reviewed by several other roentgenologists who concurred in this diagnosis. Roentgen therapy was planned accordingly. No other parts of the skeleton showed any demonstrable lesions.

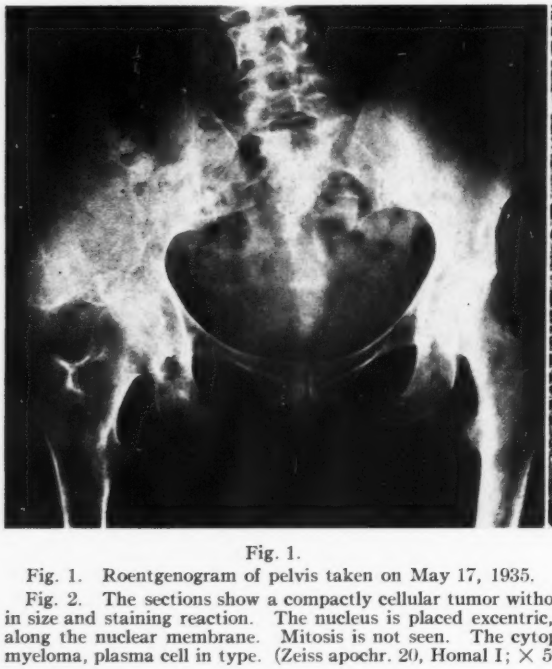

Fig. 1.

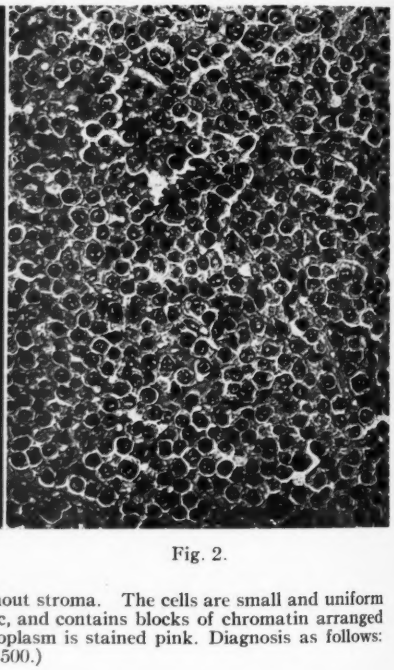

Fig. 2.

Fig. 1. Roentgenogram of pelvis taken on May 17, 1935.

Fig. 2. The sections show a compactly cellular tumor without stroma. The cells are small and uniform in size and staining reaction. The nucleus is placed excentric, and contains blocks of chromatin arranged along the nuclear membrane. Mitosis is not seen. The cytoplasm is stained pink. Diagnosis as follows: myeloma, plasma cell in type. (Zeiss apochr. 20, Homal I; × 500.)

A few days later the patient consented to have a biopsy done. At the operation the shell of the bone appeared to be very soft and yielded under finger pressure. Exploration showed that it could be cut with a knife and the interior curetted as a gelatinous bloody mass. Microscopic examination of the sections revealed a typical plasma-cell myeloma (Fig. 2).

In reviewing our previous roentgen diagnosis we still feel that the appearance of the lesion is that of a giant-cell tumor. While the most

frequent sites are the lower end of the femur, the upper end of the tibia, and the lower end of the radius, giant-cell tumor has been seen in the ilium. Clinically, there was a history of trauma followed by pain and the development of a tumor. On the other hand, myeloma occurs most frequently during the sixth decade of life, involving, as a rule, the ribs, spine, pelvis, and upper ends of the femora. The multiplicity of the lesions is a most striking feature. This observation teaches us again not to place the diagnosis entirely on *one* single method of examination.

SYPHILITIC GUMMA OF THE LUNG

(CASE REPORT)

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Any manifestation of the acquired form of syphilis of the lung is a comparatively rare pathologic entity. The case herein reported, however, seems to justify the diagnosis.

In reviewing the literature of recent years, we found no case in which the roentgen examination disclosed the well circumscribed appearance without associated inflammatory changes that this case presented. This was probably due to the fact that their films of the chest were made later in the course of the disease than were ours, and, therefore, at a time when secondary inflammatory changes had altered the x-ray appearance. We were unfortunate in not being able to repeat the roentgen examination during the last three months of life. The extensive secondary inflammatory changes which can accompany such a lesion were evidenced by the postmortem report of this case.

Figures 1 and 2 show the x-ray appearance of the lesion three months before death.

Some pathologists hold that a lesion of tertiary syphilis manifesting itself in the lung usually cannot be considered syphilitic in origin unless it shows definite regression under anti-syphilitic therapy. Cases have been reported (1 and 2) which tend to refute this contention. We had no opportunity for making x-ray or any other examination after anti-syphilitic therapy inasmuch as this patient did not return to the clinic after discharge from the hospital. We do not feel, however, that this fact casts any doubt upon the diagnosis in this case.

Another interesting and unusual feature of this case was the fact that there was no other evidence of visceral syphilis aside from the pulmonary findings.

Case 1. V. C., a colored man, hospital No. 0-91, aged 34 years, unemployed but previously a chef, was admitted to the service of Dr. Robert Barton on Jan. 4, 1935, and discharged on Jan. 13, 1935. He died at home on March 29, 1935. On admission, the patient had the following complaints: dyspnea and productive cough with rusty sputum of eight months' duration, and a loss of 40 pounds in weight during that time. More recently there had been vague chest pains, and ten days previous to admission a gross hemoptysis.

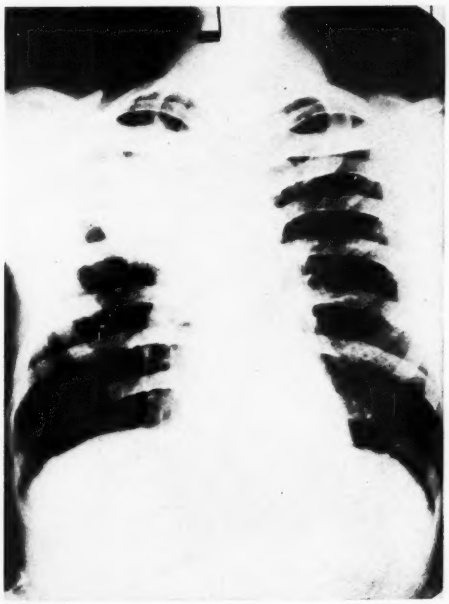

Fig. 1. Frontal view of the chest three months before the patient's death.

Past History.—In 1917, while in the army, the patient developed a persistent non-productive cough which lasted for three months. Following this, he was in good health until 1926, when he developed the same symptoms as in 1917, which lasted this time about two months. The patient was again symptom-free until in April, 1934, which marked the onset of the symptom-complex complained of on admission, and which had caused semi-invalidism since that time. There was a history of primary penile lesion 18 years previous, at which time the treatment consisted of "six shots in the arm" at weekly intervals. He also had gonorrhea at that time.

Physical Examination.—The patient was well developed but somewhat under weight. There was no apparent distress except for slight dyspnea and an occasional productive cough. His temperature was 98.4 degrees, pulse 93, blood pressure 124/78, and respirations 20 per minute. His pupils were equal and reacted to light and accommodation. His

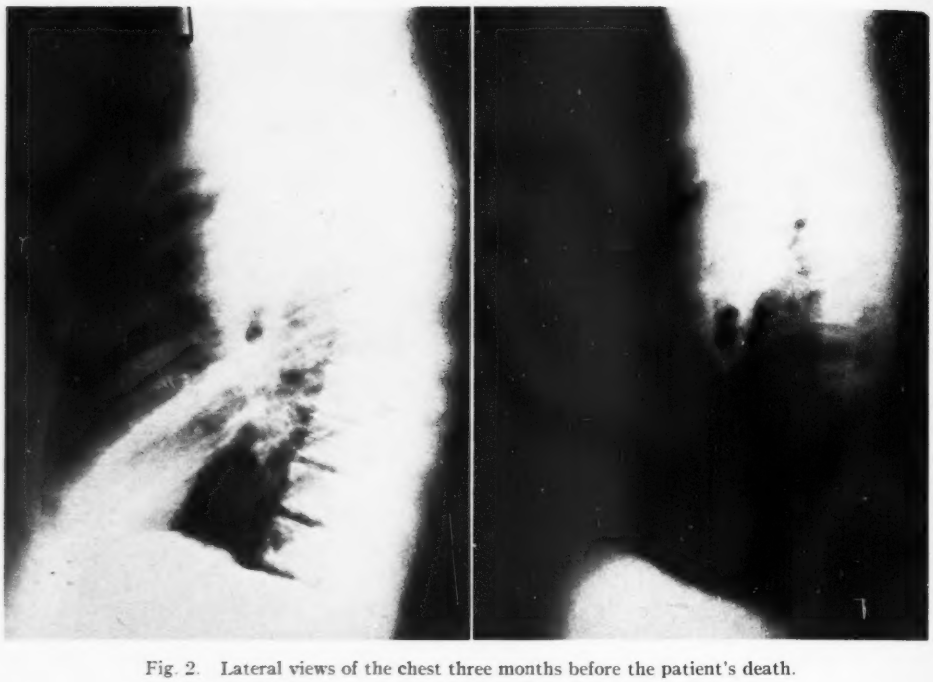

Fig. 2. Lateral views of the chest three months before the patient's death.

chest showed equal and symmetrical expansion. A few râles were heard over the right lung posteriorly, with an area of dullness in the center and extending upward and medially where slight diminution in breath sounds was noted. There were râles over the apex anteriorly. With the exception of an old scar on the prepuce, there were no further pathologic findings on physical examination.

Laboratory Data.—Urinalysis was negative. The blood count was 3,860,000 red cells, 6,100 white cells, 75 per cent hemoglobin (Sahli), and a normal differential. Repeated sputum examinations failed to reveal the tubercle bacillus. Blood Wassermann reaction was 4 plus.

Roentgen Examination of the Chest.—A dense circular shadow, 6 × 7.5 × 6.5 cm. in size was noted in the medial portion of the right upper lobe, apparently arising from the upper pole of the right hilum. There was moderate surrounding bronchovascular infiltration, and atelectasis in the periphery of the first anterior interspace. A roentgenologic impression of neoplasm was given. A bronchoscopic examination by Dr. Abell D. Hardin, on Jan. 8, 1935, revealed bleeding from the mucosa of the trachea near its bifurcation and from the right upper main stem bronchus. All structures were edematous, and there appeared to be extrinsic pressure upon the lumen of the right main stem bronchus. The appearance did not warrant an attempt at biopsy, and the bronchoscopist's opinion was "probable right lung abscess."

While in the hospital, 20 minims of potassium iodide was administered by mouth four times daily, and 3 grains of bismuth salicylate intramuscularly every five days. No other procedures in the way of diagnosis or treatment were considered indicated with the patient in the hospital, and he was referred to the outpatient anti-syphilitic clinic for further treatment. He returned to this clinic on two occasions, receiving treatment each time after which he was confined to his bed at home. The city physician made several visits to his home, and the course until death was that of slowly developing lung abscesses on both sides with a terminal septic pneumonia.

NECROPSY

Aside from the pulmonary findings and two small abscesses on the anterior surface of the liver, there were no important pathologic changes observed.

Gross.—The upper and middle lobes of the right lung are covered with a thick hyalinized pleura. This portion of the lung is firm and cartilaginous in consistency. On section, there is a large cavity measuring 12 centimeters in diameter of the middle of the upper lobe. This

cavity has well-defined walls which are lined with a grayish-brown necrotic exudate. The lumen is filled with an exudate in which there are small friable and granular masses of débris which measure from 1 to 10 millimeters. Two smaller cavities measuring 2 and 5 centimeters, respectively, are near the larger cavity and have a similar appearance. There are dense hyalinized bands of connective tissue extending from the hilus toward the periphery, surrounding all the cavities and the bronchi, and replacing most of the normal lung tissue. This area of fibrosis is not circumscribed but gradually fades out into the substance of the lung before it reaches the pleura. There is a moderate increase in fibrous connective tissue in the lower lobe which contains several small areas of consolidation, grayish-brown in color and varying in size from 1 to 3 centimeters in diameter. Hilus nodes are filled with anthracotic pigment. In the posterior portion of the left lung there are multiple small grayish areas of consolidation from 1 to 2 centimeters in diameter.

Microscopic.—There is an extensive proliferation of fibrous connective tissue in the lung, which has destroyed many alveoli in the upper and middle lobes. Coagulation and liquefaction necrosis of the lining tissue of the cavity are extensive. This necrotic débris is undergoing organization with many thin-walled capillaries surrounded by an infiltration of numerous lymphocytes, plasma, and endothelial cells. Fibroblasts are numerous. Reversion of alveolar epithelium is extensive. Alveoli are filled with an exudate consisting of fluid, plasma, and endothelial cells. Most of the blood vessels of the lung are surrounded by similar cells. Hypostatic pneumonia is present in the lower lobe of the right lung and in the posterior portion of the left lung. The final diagnosis was: syphilitic gumma of the lung with surrounding syphilitic pneumonia; multiple lung abscesses; purulent bronchitis; abscesses of the liver, and acute degeneration of the viscera.

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SOME FEATURES OF A CASE OF MULTIPLE EXOSTOSES—DIAPHYSEAL ACLASIS (KEITH)

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The patient, G. B., an undersized man of 58 years, was admitted to the hospital suffering from cerebral concussion, the result of a motor accident. All limbs were greatly misshapen, and a later inquiry elicited the following facts.

The patient was the youngest of a family of eleven children, none of whom showed any bony abnormalities. As far as could be ascertained, no parental relatives were similarly afflicted, but the patient's only child, a girl, developed swellings on the inner side of each knee at the age of 6 years and six months. She died of influenza three years later.

The general health of the patient was good and he has had no illnesses of a serious nature. The deformities of the limbs, which first attracted attention, in the region of the knees when the patient was three years old, "progressed to other joints, but ceased when growth stopped at the age of 12 years." They were never painful and caused little real disability, the patient being able to carry on his work as a surveyor.

The patient, whose height measured 5 feet 1 inch, was grossly deformed. There was marked irregularity in the contour of the arms, particularly at the wrists, and in the upper half of each humerus. The right radius was bowed with the convexity outward. Immediately below the knees and just above the ankles, large projections could be seen. The metaphysial areas were the sites of the most pronounced deformities, which showed a remarkable similarity in corresponding parts of each limb.

Movements at the joints were surprisingly free and painless, and examination of the other systems revealed no notable features. No clinical evidence of endocrine abnormality was detected, and the Aschheim-Zondek test was negative. Radiological examination confirmed the diagnosis of diaphyseal aclasis, and showed the well known features of the disease. The characteristic changes were, as usual, best seen at the sites of maximum growth in the long bones, and their symmetry was striking. The epiphyses were of normal shape, likewise the vertebræ, skull, and sternum.

The accompanying skiagram (Fig. 1) shows the condition in the right pectoral region where two of the exostoses seem worthy of comment.

Originating from the inferior margin of the glenoid cavity is a cauliflower exostosis representing an excrescence in the neighborhood of

a secondary center of ossification. This swelling could be readily felt in the axilla. Scapular exostoses are not uncommon and occur most frequently in the region of the vertebral border.

Reference is often made to irregularity of the ribs, and definite outgrowths are sometimes recorded. The symptomless costal exostosis in the present case was also palpable. It appeared as a mushroom-shaped projection arising from the posterior part of the right first rib near the tubercle—also the site of a secondary ossific center.

Fig. 1. Roentgenogram of the right pectoral region, showing the costal and the scapular exostoses alluded to in the text.

EDITORIAL

LEON J. MENVILLE, M.D., *Editor* HOWARD P. DOUB, M.D., *Associate Editor*

NON-TROPICAL SPRUE

(CHRONIC IDIOPATHIC STEATORRHEA)

In the minds of most North American physicians, sprue has always been considered a specific tropical disease, endemic in character, which is rarely if ever encountered among natives of temperate climates. During recent years, however, an increasing number of reports of sprue-like diseases occurring in non-tropical climates have appeared in the literature, and there are now probably well over a hundred such cases on record. It is probably considerably more common than generally believed. There has been no uniformity in the nomenclature used in describing the condition, and it appears variously as "non-tropical sprue," idiopathic steatorrhea," "adult celiac disease," "Gee-Herter's disease," and so forth.

The condition is one of particular interest because of its relation to deficiency diseases and because of the present interest in the pathologic physiology of the small bowel. The principal clinical features of the disease are (1) steatorrhea, with or without diarrhea, (2) gastro-intestinal disturbances, (3) loss of weight and muscular wasting, (4) defective metabolism of calcium and phosphorus, leading in certain cases to tetany and osteoporosis, (5) physical stunting or rachitic stigmas, and (6) anemias of various types and degrees of severity. Among the most remarkable features of the disease is the variability of the clinical picture and the tendency to remission and relapse.

It has been suggested that the disease is of an infectious nature, but there is no bacteriologic or pathologic evidence to support this view. The condition may represent a true deficiency disease, and the recent work of Rhoads and Miller[1] seems to indicate the validity of this hypothesis. Their studies on tropical sprue seem to show that the condition may arise in three ways: (1) by dietary deficiency in respect to the extrinsic factor; (2) by lack of the same gastric enzyme which is absent in pernicious anemia, and (3) by inability to absorb the product of interaction of the first two. It is assumed that differences in the relative importance of each factor may be responsible for variations in the clinical picture. A third conception of the disease, which is perhaps more useful to physicians practising in non-tropical climates, and of particular interest to roentgenologists, is that the syndrome of sprue may not necessarily constitute a specific entity but may be produced by various diseases of the small bowel, by various deficiency states, or by any condition that seriously interferes with absorption from the upper portion of the intestinal tract. Fairley and Kilner[2] have shown that gastrojejunocolic fistula can produce symptoms closely comparable to those of sprue.

The evidence in favor of a deficiency state is very strong and constitutes the best single explanation for the etiology of both the tropical and non-tropical forms of the disease. Whether this deficiency is a primary or secondary condition is as yet uncertain. Until further information in regard to the functional and anatomic disturbances of the small intestine in both conditions becomes available, the interrelation of the non-tropical and tropical varieties of this syndrome will remain an unsettled problem. In this regard the roentgenologist has an opportunity to play a significant rôle. Thaysen,[3] who, because of his extensive studies in this field may be regarded as an authority, inclines to the belief that celiac disease in children, tropical sprue, and the non-tropical variety are closely related if not identical, and suggests their grouping under the head of "the celiac affection."

References to roentgenologic studies of the gastro-intestinal tract in tropical sprue are con-

[1] Rhoads, C. P., and Miller, D. K.: Intensive Liver Extract Therapy of Sprue. Jour. Am. Med. Assn., Aug. 11, 1934, **103**, 387–391.

[2] Fairley, N. H., and Kilner, T. P.: Gastrojejuno-colic Fistula, with Megalocytic Anemia Simulating Sprue. Lancet, Dec. 19, 1931, **2**, 1335–1341.

[3] Thaysen, Th. E. Hess: Non-tropical Sprue: A Study in Idiopathic Steatorrhea. Levin and Munksgaard, Copenhagen, 1932, 258 pages.

fined largely to an article by Pillai and Murthi,[4] who studied nine cases. They found in the acute forms no indication of loss of tonus or motility or other change in the stomach or intestine. In the subacute state there was slight loss of tonus and vigor of peristalsis of the stomach, with consequent delay in passage of its content. The same was true of the cecum and colon. The small intestine emptied rapidly and spots of barium retained in the upper part of the cecum were interpreted as evidence of ulceration. In the chronic state, changes were similar but more marked. There was no evidence of local ulceration of the small bowel.

Roentgenologic observations reported in the literature concerning the non-tropical variety have been limited to the gastro-intestinal tract and skeletal system, chiefly the latter. Osteoporosis and osteomalacia have been noted frequently, and it is interesting that these changes are comparable to those observed in cases of avitaminosis and hunger osteomalacia. Dilatation and redundancy of the colon have been commonly observed. Radl and Fallon[5] were the first to record roentgenologic abnormalities of the stomach and duodenum in non-tropical sprue. In their case marked narrowing of the second and third parts of the duodenum, which suggested ulceration with periduodenal adhesions, was noted. An ulcer was also observed in the first portion of the duodenum, and this produced gastric retention for which gastroenterostomy was done. Mackie[6] reviewed the general literature of non-tropical sprue and reported one case in which roentgenologic studies revealed dilatation of the coils of the jejunum and small intestinal hypomotility. Independently Snell and Camp[7] had reported in detail concerning definite roentgenologic changes observed in the stomach and small intestine in four of a group of seven cases of non-tropical sprue. These authors state:

"It is significant that in all of the cases in this group in which we were able to make an adequate study of the intestinal tract during the active stages of the disease, definite roentgenologic changes in motility and in the appearance of the mucosa of the small intestine were observed. Changes in the stomach and colon were less constant. In the usual case the duodenum was dilated and the mucosal markings were thickened. In the jejunum and ileum there was a definite smoothing out of the irregular shadows of the valvulæ conniventes, and clumping of the barium in smooth, sausage-like masses. After the bulk of the opaque meal had passed, remnants of barium adhered to the walls of the jejunum, giving it a peculiar 'fleck-like' appearance. In the more severe cases the markings of the valvulæ conniventes were entirely lacking. Dilatation of the jejunum was common, although the contractions incident to peristalsis were readily observed fluoroscopically. Hypomotility was the rule in active cases. The regression of the changes and restoration of the mucosal pattern toward the normal, coincident with improvement in the clinical symptoms, were quite striking.

"The roentgenologic findings suggest an inflammatory condition, with edema of the mucosa involving, especially, the small intestine and, less frequently, the stomach and colon. The complete absence of mucosal markings in the severe cases suggests destruction or atrophy of the mucous membrane. The regression of these changes incident to clinical improvement and the changes described at necropsy in similar cases would seem to substantiate these deductions, although it is recognized that there is considerable discussion concerning the significance of the postmortem findings.

"It is not held that these roentgenologic observations are characteristic only of non-tropical sprue, since they may occur in varying degrees in any diffuse inflammatory condition of the intestinal tract. Their presence, however, constitutes tangible evidence during life of alterations in the gastro-intestinal tract in this disease which have been suspected clinically and confirmed at necropsy."

Mackie and Pound,[8] in a roentgenologic and clinical study of changes in the gastro-intestinal tract in deficiency states, observed roentgenographic changes in the small intestine in 29 of 37 cases of chronic ulcerative colitis and in

[4] Pillai, M. J. S., and Murthi, K. N.: Radiological Signs in Cases of Sprue: A Study of Nine Cases. Indian Jour. Med., June, 1931, **12,** 116; abstr. in Trop. Dis. Bull., January, 1932, **29,** 8.

[5] Radl, R. B., and Fallon, Madeleine: Non-tropical Sprue, with Duodenal Involvement and Tetany. Arch. Int. Med., October, 1932, **50,** 595–604.

[6] Mackie, T. T.: Non-tropical Sprue. Med. Clin. of No. Am., July, 1933, **17,** 165–184.

[7] Snell, A. M., and Camp, John D.: Chronic Idiopathic Steatorrhea: Roentgenologic Observations. Presented before Minnesota Society of Internal Medicine, Minneapolis, May 15, 1933. Published in Archiv. Int. Med., April, 1934, **53,** 615–629.

[8] Mackie, T. T., and Pound, R. E.: Changes in the Gastro-intestinal Tract in Deficiency States. Jour. Am. Med. Assn , Feb. 23, 1935, **104,** 613–618.

three cases of non-tropical sprue. Their observations in the latter group confirmed those reported by Snell and Camp. More recently Snell, Camp, and Watkins[9] have reported 15 cases of non-tropical sprue in which the roentgenologic changes in the gastro-intestinal tract confirmed their original observations.

According to Mackie and Pound, "the nature of these phenomena are obscure. Three different mechanisms may contribute. They may result from actual infection of the intestinal wall, they may depend on local allergy, or they may represent an effect of the deficiency state. Demonstration of the changes in the small intestine raises the two fundamental questions of their importance and their relation to the deficiency syndrome. They are constantly present and most marked in the cases showing advanced deficiency states. In the milder cases the parallelism is not exact. While the evidence does not warrant definite conclusion, the observations suggest that these changes in the small intestine are related to deficiency states and perhaps play a rôle as a conditioning factor in their development."

JOHN D. CAMP, M.D.

[9] Snell, A. M., Camp, John D., and Watkins, C. H.: Non-tropical Sprue (Chronic Idiopathic Steatorrhea). Proc. Staff Meetings of Mayo Clinic, March 20, 1935, **10**, 177–184.

ANNOUNCEMENTS

GRADUATE STUDY IN RADIOLOGY

The College of Medicine of the New York University offers opportunity for graduate study in radiology and grants the degree of Doctor of Medical Science (Med.Sc.D.) to those candidates who satisfactorily meet the requirements.

Minimum Requirements for Admission

1. Graduation from a medical college approved by New York University.
2. Completion of an internship of at least one year in a hospital approved by New York University.
3. Approval by the department in which the graduate work is to be done.

Requirements for the Degree

1. A period of study totalling not less than three years of full-time work or the equivalent in New York University or in laboratories or hospitals recognized by it, at least one year of which must be spent in the Medical College of New York University.
2. A satisfactory performance in written, oral, and practical examinations and an acceptable thesis based on original work.

For further information address the Assistant Dean, 477 First Avenue, New York City.

A CORRECTION

INTENSITY AND DOSAGE NEAR RADIUM NEEDLES. By G. C. Laurence, Ph.D. RADIOLOGY, August, 1935, **25,** 166–181.

The author is indebted to the Editor of RADIOLOGY for the opportunity of correcting errors in the text. The formulæ on page 179 should read;

$$f_1 = \frac{1}{\left(\frac{w}{L}\right)} \tan^{-1} \left\{ \frac{w}{L} \Big/ \left(\left(\frac{w}{L}\right)^2 + \left(\frac{x}{L}\right)^2 - \frac{1}{4} \right) \right\},$$

which approaches $L^2/(w^2 + x^2)$ at great distance from the needle, and

$$f_2 = \log_e \left\{ \cot \frac{1}{2} \tan^{-1} \left(\frac{x}{w} + \frac{L}{2w} \right) \Big/ \cot \frac{1}{2} \tan^{-1} \left(\frac{x}{w} - \frac{L}{2w} \right) \right\} \Big/ f_1 \frac{w}{L}.$$

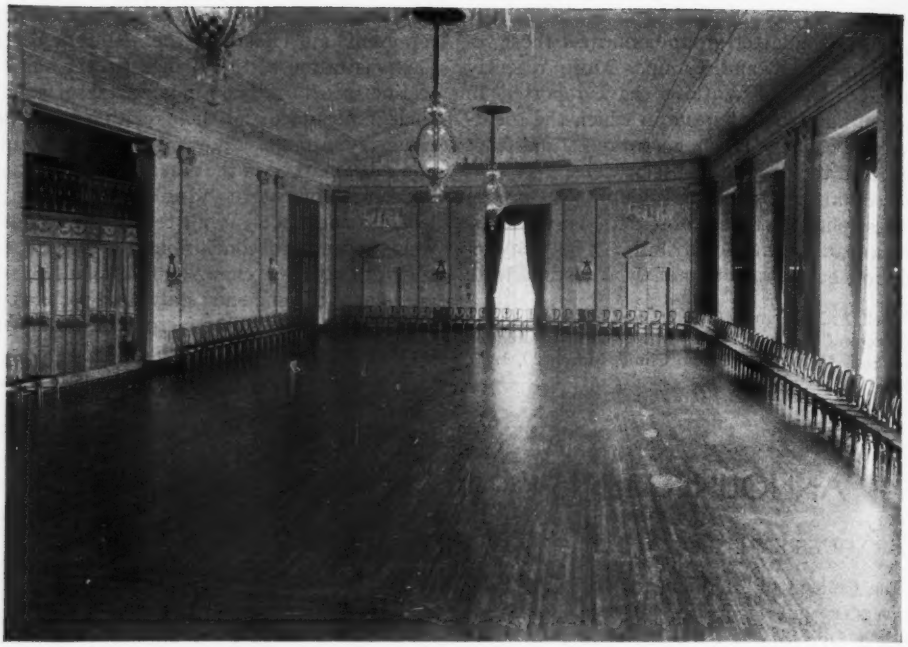
NEXT ANNUAL MEETING

HOTEL STATLER, DETROIT, DEC. 2–6, 1935

It is hoped that all members of the Radiological Society of North America have made plans to attend. From the scientific program and exhibits they will derive knowledge, new ideas, new impetus—as the case may be. From the commercial exhibit they will learn of advancements and improvements in apparatus, equipment, and contrast media.

Not to be set forth in such concrete terms yet none the less real are the advantages to be derived from contacts with fellow-radiologists. Not every one cares to admit as much, but pleasure seems to some of us to be a legitimate end in itself. After months of hard work and close confinement to office or hospital practice it does one no harm to relax a little, meet old friends, and exchange ideas.

Recognizing these diverse needs of radiolo-



Ballroom, Hotel Statler, Detroit, scene of the Society's annual banquet.

Dining room, Hotel Statler, Detroit

gists—in common with the rest of mankind—the committees in charge of our Annual Meeting have provided program, exhibits, entertainment in due parts. Every year a few ladies choose to come and such as visit Detroit will find that the wives of the local physicians have planned for them a visit to Mr. Henry Ford's Greenfield Village and museum of early Ameri-

can utilities, and also certain social affairs. As for the men, there will be a Counselors' Dinner and a stag night, occasions about which traditions of good-fellowship have grown up through the years we have been meeting together. The latter offers new men a rare opportunity to make valuable friends.

There has been an unusually active demand for commercial exhibit space, showing that the apparatus men recognize the value to them of this opportunity to show what has been developed.

If space has not been reserved for you before this date, readers would do well to wire for reservations when they read this. Names of Detroit hotels, together with rates, are to be found in October RADIOLOGY, page 508.

Hotel Statler, Detroit, where the Annual Meeting is to be held Dec. 2–6, 1935.

COMMUNICATIONS

FLORIDA STATE MEDICAL ASSOCIATION

It is always gratifying when a radiologist is chosen by his fellow-members to fill an outstanding place in his local, state, or national medical body. The JOURNAL wishes to call attention to such an instance wherein O. O. Feaster, M.D., radiologist at St. Anthony's Hospital, St. Petersburg, Florida, has been chosen President-elect of the Florida State Medical Association. Dr. Feaster was one of the organizers of the Florida Radiologic Society.

MID-SUMMER RADIOLOGICAL CONFERENCE, DENVER

All concerned with this project are gratified over its successful achievement, and, therefore, it is a matter of gratification to the Editor of

RADIOLOGY to have received letters from two members of the Radiological Club of Denver saying that the notices in this JOURNAL were instrumental to that end. The JOURNAL is ready at all times to co-operate with sectional radiological associations, among whose members the Radiological Society of North America is represented.

ORTHOPEDIC LIBRARY

The Medical Institution, of Liverpool, England, is commemorating the work of two famous surgeons by forming a Hugh Owen Thomas and Robert Jones Library of Orthopedic Surgery in which, it is hoped, every phase of that branch of surgery will be represented. An appeal is, therefore, made through the Liverpool Medico-chirurgical Journal for contributions of books and articles on the subject. These will form the nucleus of what, it is hoped, will be a complete Orthopedic Library in which the student, the post-graduate, the physician, the surgeon, and the radiologist may learn all that is being done in this branch of the work, and may refresh themselves at the spring of knowledge which flows from the works of the two men in whose names the Library is being founded.

The fame of Hugh Owen Thomas and Sir Robert Jones will live high amongst the names of the great surgical figures of all time. They have left imperishable records in the history of surgery, and they have formed a science where none previously existed. They have lit a beacon whose light has spread to every corner of the surgical world, and have opened up a prospect of recovery in the hearts of thousands who would otherwise be destined to useless crippledom.

They have done this through the force of their teaching and examples, but they have done more in that they have laid down the unalterable basis of treatment on which the inevitable progress will be founded.

It is hoped, therefore, that all who read this, who have themselves contributed toward the literature of orthopedic surgery, will send to the Liverpool Medical Institution a copy of their books or articles to help in the formation of the Hugh Owen Thomas and Robert Jones Library, so that this effort, which is unique, may also be complete in its accomplishment.

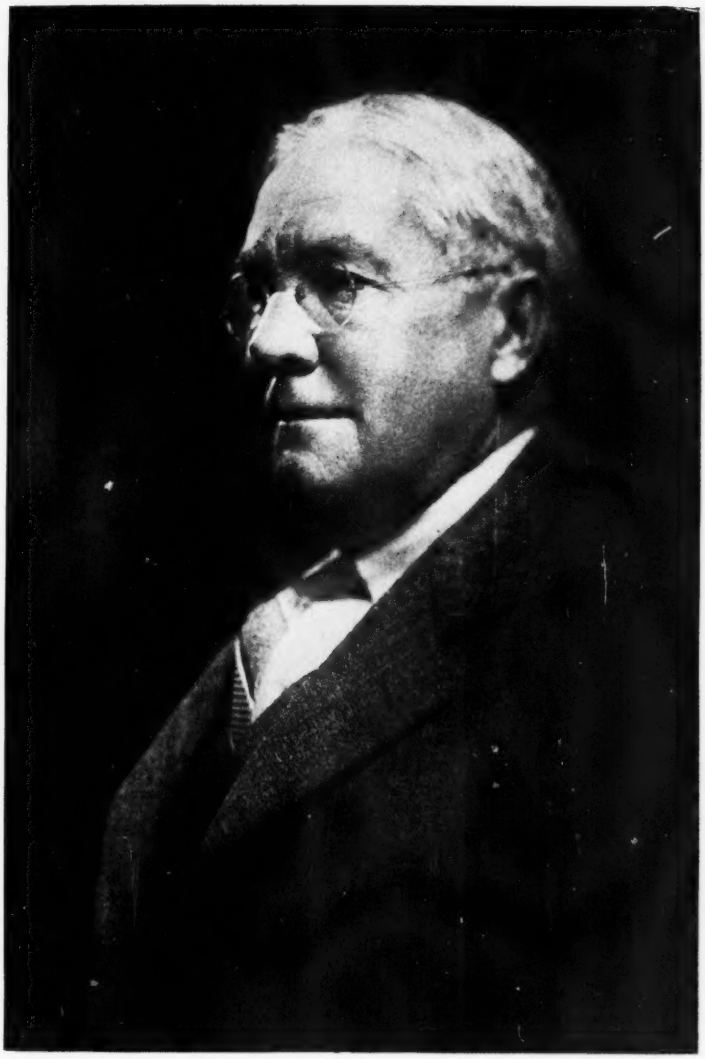
It is medicine's proud boast that "science knows no boundaries," so this appeal for books may find many responses among American radiologists. The address of the Medical Institution is 114 Mount Pleasant, Liverpool 3, England.

IN MEMORIAM

JOSEPH COLT BLOODGOOD, M.D.

The actual clinical study of cancer by research methods had just begun when Dr. Joseph C. Bloodgood started his work at Johns Hopkins Hospital. The beginnings in this hospital were forty years ago, when a laboratory was started in connection with the operating room. Pieces of tumors were brought there for study after operation, and records kept. In connection with this study Dr. Bloodgood brought laboratory examination into the operating room. The microscope was placed at the operating table. By this method countless legs, arms, breasts, and other organs have been saved from mutilation, and many deaths prevented. The profession as a whole had not been educated in this branch of medical science, and had not learned to employ the microscope in the study of the living patient. By advocating control of therapeutic procedures on the breast and bones in particular, Dr. Bloodgood rendered an invaluable service in the treatment of these diseases. His interpretation of chronic cystic mastitis and of giant-cell tumors of the bone as benign lesions, and his advocacy of microscopic study before radical procedures were attempted have saved hundreds of patients throughout the world from needless mutilation.

It was soon found possible to advance the interpretation of laboratory studies made on patients while still in the hospital by extending the record, not only throughout their stay, but by following the patients with letters from time to time for the rest of their lives. Dr. Bloodgood instituted, about 1910, an extensive follow-up system in connection with all cancer patients. In the next twenty years many thousands of dollars were spent privately, in addition to the hospital contributions, in keeping records and in following patients by letter. By this method, and by microscopic studies many fundamental contributions have been made. The thoroughness with which records and material from cancer cases have been recorded and preserved makes this laboratory a most valuable library for all those undertaking



The late JOSEPH COLT BLOODGOOD, M.D., Johns Hopkins Hospital and University, Baltimore.

serious investigation on the cause or control of cancer.

In the study of the records it soon became manifest that much of the material saved dealt largely with the terminal stages of cancer. This fact, together with the fact that the examinations recorded and made in the hospital were often too meager, hindered progress. To obtain worthy scientific records and to see patients in all phases of cancer, a new movement was started. It was decided to educate the profession and the public in the early signs and symptoms of cancer so that the patients would come for consultation at the beginning of the disease.

One of Dr. Bloodgood's chief interests has been the spreading of information among the laity concerning those aspects of cancer which are influential in bringing suspected cases of cancer under the observation of the physician at the first signs of the disease, when it is still in its curable stages. This educational effort in the field of cancer, which was started some seventeen years ago by such pioneers as Cullen and Bloodgood and is being continued by the American Society for the Control of Cancer and by special State organizations such as those in New York and Massachusetts, has brought about changes in the clinical aspects of cancer, which are rapidly revolutionizing practice in this sphere of medicine.

This work stands as an enduring memorial to Dr. Bloodgood, who passed away Oct. 22, 1935. His name is an honored one among radiologists, many of whom not only respected his broad knowledge and experience, but felt his personal charm and genial humor.

RADIOLOGY pays honor to his memory.

BOOK REVIEWS

X-RAYS IN THEORY AND EXPERIMENT. By ARTHUR H. COMPTON, PH.D., SC.D., LL.D., Nobel Laureate, 1927, Charles H. Swift Distinguished Service Professor of Physics, University of Chicago, and SAMUEL K. ALLISON, PH.D., Associate Professor of Physics, University of Chicago. Second Edition of "X-rays and Electrons," by Arthur H. Compton. A volume of 828 pages, with 279 illustrations; cloth. D. Van Nostrand Company, Inc., New York, 1935. Price, $7.50.

A. H. Compton published his well-known book, "X-rays and Electrons," in 1926. It quickly gained wide favor among physicists. After its publication there were new and important developments of the theories underlying roentgen-ray phenomena, and so Compton prepared a revised and more comprehensive edition, presenting the newer roentgen-ray experiments and theories in co-operation with S. K. Allison. Compton wrote the introductory chapter and the chapter on scattering. In the preface he gives his collaborator credit for the preparation of the greater part of the book which includes discussion of roentgen rays and crystals, dispersion, absorption, and roentgen-ray spectra.

The book is not exactly easy reading for the average medical roentgenologist. It contains much valuable information not only on points of general interest about roentgen rays but also in the field of practical application in roentgen diagnosis and therapy. A list of the main chapters gives an idea of the vast territory covered.

Chapter I The Discovery and Properties of X-rays;
Chapter II The Production of X-rays;
Chapter III The Scattering of X-rays;
Chapter IV Dispersion Theory Applied to X-rays;
Chapter V The Study of Crystal Structure by Means of X-rays;
Chapter VI The Intensity of Reflection of X-rays from Crystals;
Chapter VII Phenomena Associated with the Ejection of Photo-electrons by X-rays;
Chapter VIII The Interpretation of X-ray Spectra;
Chapter IX Some Accurate Methods of X-ray Wave Length Measurement and Their Results.

Numerous appendices contain mathematical deductions and formulæ, tables of atomic constants, wave lengths of roentgen-ray spectrum lines, critical absorption wave lengths, absorption coefficients, etc.

The roentgenologist will be especially interested in the chapters on production and measurement of the roentgen rays. The production of the continuous and characteristic x-ray spectra and their dependence upon voltage, target material, etc., is discussed in detail. Measurement of the roentgen rays by studies of their absorption and scattering in various media as well as by x-ray spectroscopy are explained at great length. Of particular interest is the discussion of the ionization in gases and its useful-

ness in measuring the relative intensities of the rays.

This book states that it "calls attention to those aspects which seem of the most fundamental physical significance." It is an excellent and comprehensive presentation of what is known in the roentgen-ray field at the present time.

MANUAL OF RADIOLOGICAL TECHNIC. L. R. SANTE, M.D., Professor of Radiology, St. Louis University School of Medicine; Radiologist to St. Louis City Hospital and St. Mary's Hospital, St. Louis. Published by Edwards Brothers, Inc., Ann Arbor, Michigan, 1934. A volume of 157 pages, with 141 illustrations. Price, $4.50.

Many roentgenologists, particularly those associated with large institutions or medical schools, have undoubtedly had a desire at one time or another to compile for the use of their students and technicians a manual of roentgenographic technic. Dr. Sante has carried this idea to completion and produced a manual of x-ray technic designed to serve, first, the radiologist who, in his administration of a large department of radiology, is constantly called upon to train and supervise large groups of technicians; second, the technician himself, and third, the general medical profession.

The first eight chapters are devoted to a short historical sketch concerning the discovery of the x-rays, and a practical and concise consideration of the physics of magnetism and electricity, the x-ray tube, and the production of x-rays; the physical properties of x-rays; the calibration of x-ray machines; the essential factors of radiography, radiographic procedure, and dark room technic. Many of these chapters contain useful, practical information not heretofore found in books of this sort.

The major portion of the manual is devoted to a discussion of the standard positions for all phases of radiography. This section is excellently illustrated by photographs, roentgenograms, and anatomic drawings. A unique and most valuable feature of this part of the manual is a discussion termed "Roentgenological Consideration" which appears for each position portrayed.

To make the manual more elastic it has been published by the lithoprinting method which makes it possible for any radiologist to eliminate any particular procedure or technic which he does not desire and to introduce additional rules or regulations particularly applicable to his own department, at very small cost.

IN MEMORIAM

HARRY B. PODLASKY, M.D.

Word has been received of the death, on November 8, of Harry B. Podlasky, M.D., of Milwaukee, Wisconsin. Dr. Podlasky has been an honored member of the Radiological Society of North America, among whose members are numbered many who will be grieved to learn of his passing. He was a member of the Editorial Staff and a contributor to RADIOLOGY.

We hope to print a sketch of Dr. Podlasky in the next issue.

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J. E. Habbe, M.D., of Milwaukee, Wisc.
Hans W. Hefke, M.D., of Milwaukee, Wisc.
H. A. Jarre, M.D., of Detroit, Mich.
E. A. Pohle, M.D., Ph.D., of Madison, Wisc.

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APPARATUS

Thicknesses of Aluminum to be Used in Addition to Copper Filters. A. Mutscheller. Am. Jour. Roentgenol. and Rad. Ther., July, 1934, **32,** 92, 93.

The most efficient filter of aluminum to be used as a secondary filter to absorb the characteristic soft radiation emitted by the copper filter would be that thickness of aluminum just sufficient to absorb such soft radiation. Experiments by Mutscheller showed that a filter of $^1/_4$ mm. or, at the most, $^1/_2$ mm. of aluminum is quite sufficient to absorb all harmful radiation arising from the $^1/_2$ mm. of copper, and that no useful results are gained from any additional material.

J. E. HABBE, M.D.

A New Method of Measuring the Short Rays in the Sun Spectrum. Julius Brinkmann. Strahlentherapie, 1935, **53,** 424–454.

The method is based on measurements with a set of "double" thermocouples arranged according to the compensation principle in connection with adequate filters. The output of a quartz mercury vapor lamp was also determined and found to be 2.9×10^{-5} watt per sq. cm at 1 meter distance.

ERNST A. POHLE, M.D., Ph.D.

Regarding the Additional Aluminum Filter in Roentgen Therapy. M. Grunberg and W. Johner. Strahlentherapie, 1935, **53,** 528–535.

Measurements of the secondary irradiation from copper filters within and outside of the primary beam showed that for F.S.D. of 20 cm. and more, this radiation may be neglected. The addition of an aluminum filter in deep therapy after filtration of the primary radiation through 0.5–3 mm. Cu is, therefore, superfluous.

ERNST A. POHLE, M.D., Ph.D.

Our Experience with New Siemens "Momentan" Dosage Meter. Herbert Aretz. Strahlentherapie, 1935, **53,** 536–542.

The author briefly describes an ionization instrument which permits the determination of the output of an x-ray tube in r/min. A double scale is provided for 0–12 r and 0–100 r/min. The instrument is said to be easy to operate and has a radio-active standard for checking the calibration.

ERNST A. POHLE, M.D., Ph.D.

Scattered Radiation Emitted by Patients Undergoing Roentgen Deep Therapy. H. W. Ernst and Paul Ott. Strahlentherapie, 1935, **53,** 595–604.

The authors measured the scattered radiation emitted by a patient subjected to roentgen deep therapy using the new type of Siemens dosimeter with a cellophane chamber. The latter is supposed to be independent of the wave length within the spectral region examined. After a brief orientation as to the distribution of the scattered radiation emitted by the patient by means of a pinhole camera the rays were measured at 50–200 cm. distance within and without the primary beam. Based on Mutscheller's tolerance dose it appears that during a treatment the operator should not enter the therapy room. However, due to the longer wave length of the secondary radiation a lead rubber apron, as customary in fluoroscopic work, suffices for the protection of the physician. At one meter distance from the patient and behind such a lead rubber apron the dose is 4–5 $\times 10^{-5}$ r per second.

ERNST A. POHLE, M.D., Ph.D.

CANCER (THERAPY)

Post-operative Irradiation in Carcinoma of the Breast. G. Schwarz. Strahlentherapie, 1935, **53,** 674–681.

Several cases have been observed and published wherein skin metastases appeared in the anterior breast region following radical removal for carcinoma after very heavy doses of roentgen rays had been applied post-operatively. The metastatic nodules were limited to the irradiated skin area. The author has used for several years, therefore, a "milder" procedure. In the first place, he advocates a fairly soft radiation (100 kv., 1 mm. Al) because the skin is injured less. One series consists of from six to eight sittings, given daily, with a total dose of from 900 to 1,200 r applied over the anterior chest. If possible, one large area is given to the axillary and supraclavicular region at 70 cm. F.S.D. If the arm cannot be raised sufficiently, two separate areas are used at 40 cm. F.S.D. He repeats the series every five weeks so that five months after operation a total of from 3,600 to 4,800 r has been applied. After the sixth month the intervals between series are increased to three, six, and twelve months, adding each time 1,200 r. The experience with this treatment has been very satisfactory.

ERNST A. POHLE, M.D., Ph.D.

Curietherapy of Carcinoma of the Mouth and Pharynx. V. Palumbo. Strahlentherapie, 1935, **53,** 651–657.

In the treatment of intra-oral lesions the author uses external telecurietherapy followed by direct (local) irradiation and again followed by external telecurietherapy. Twenty years' experience has convinced him that the results obtained by irradiation are far superior to those of surgery. No technic is given.

ERNST A. POHLE, M.D., Ph.D.

GASTRO-INTESTINAL TRACT (DIAGNOSIS)

Duodenal Diverticula. L. Minucci del Rosso. Il Policlinico (Sez. Chir.), April 15, 1935, **42,** 236–260. (Reprinted by permission from British Med. Jour.,

June 29, 1935, p. 104 of Epitome of Current Medical Literature.)

The author has collected 68 cases of duodenal diverticula in patients aged from 22 to 87, the first of which was reported by Chomel in 1710, and the last two by himself—in a woman aged 61, who had two diverticula, and in a man aged 68, who had one diverticulum. As a rule there is only a single one. In 90 per cent of the cases it is situated between the second and third parts of the duodenum, and is confined to the segment of the duodenum corresponding to the pancreas. Islands of accessory pancreas are not infrequently found in the wall of the diverticulum.

According to Sabatini, there are three types of clinical syndrome caused by duodenal diverticula. In the first the symptoms are those of duodenal ulcer, the anatomical foundation in such cases being diverticulitis, compression or torsion of the sympathetic, or torsion of the duodenum. In the second type the symptoms are those of acute or chronic pancreatitis, and in the third those of inflammation of the gall bladder, due to compression of the biliary tract.

Of the author's 68 cases, 22 ended fatally, the chief causes of death being myocarditis, pneumonia, hemorrhage, and the shock of the operation. Of 16 cases in which operation (posterior gastro-enterostomy or resection of the diverticulum) was performed, 14 recovered.

Coincident Scirrhous Lesions of the Stomach and Colon: Report of Cases. Marcy L. Sussman. Am. Jour. Roentgenol. and Rad. Ther., February, 1935, **33,** 205–208.

The writer reports two cases showing coincident constricting deformities of the stomach and colon, the constrictions being in each case at two levels of the colon, while in one there was a localized narrowing of the gastric media and in the other a more diffuse narrowing of the gastric lumen. One case was proven at operation to be scirrhous carcinoma of the stomach with metastases to the bowel. The difficulties of differentiation from hyperplastic tuberculosis, advanced ulcerative colitis or amebic dysentery, and non-specific granuloma are stressed.

J. E. Habbe, M.D.

GRENZ RAYS

Absorption and Scattering of Roentgen Rays in Air and Cellophane. Hans Küstner. Strahlentherapie, 1935, **53,** 605–610.

The author found that the electron emission from cellophane after rendering it a conductor of electricity by means of graphite application equals that of air. It is, therefore, an excellent material for "air wall" ionization chambers and well suitable for measurements of long wave roentgen rays (Grenz rays). One millimeter of cellophane absorbs roentgen rays of all wave lengths the same as 106.8 cm. of air.

Ernst A. Pohle, M.D., Ph.D.

THE LARYNX

A Few End-results Following Radiation Therapy of Carcinoma of the Larynx. A. Lambadaridès. Strahlentherapie, 1935, **53,** 630–650.

The author discusses the international literature dealing with radiation therapy in carcinoma of the larynx. He presents then an analysis of 27 cases of his own, seen in Athens, Greece, during the period from 1925 to 1933. Only 12 of these had a complete course of irradiation; six were dead at the time of writing and six were alive. The survival periods of the former varied from eight months to three and one-half years. Those still alive have been under observation for periods from thirteen months to nine years. Technic: 185–300 kv., 3 ma., 50–60 cm. F.S.D., 1 mm. Zn + 2 mm. Al, 45–60 sq. cm. field size, 15–30 sittings in 18–30 days, surface dose 5,000 to 9,000 r, with twice the dose on the involved side. Occasional radium therapy was given (1–1.5 mm. Pt + ? mm. Al, 3 M.C.D. over 2 sq. cm. at 4 cm. F.S.D., 11–15 days and nights without interruption). A bibliography with 110 references is appended.

Ernst A. Pohle, M.D., Ph.D.

THE LUNGS

A Roentgenological Study of Pulmonary Ventilation: A Method for the Prediction of Normal Pulmonary Capacities Based upon Roentgen Measurements. Walter W. Fray. Am. Jour. Roentgenol. and Rad. Ther., February, 1935, **33,** 179–190.

This writer has attempted to correlate the dimensions of the lung-fields obtained teleroentgenographically with clinical determinations of pulmonary capacity. The radiographic technic adopted was a double exposure chest film made with the patient in recumbency, the greater exposure being made at maximum expiration and the lesser exposure at full inspiration. From this film the area measurements of the lung-fields at these two phases of respiration were obtained. To obtain the "roentgenological chest volume" an anteroposterior chest diameter was obtained with calipers at the level of junction of body of sternum with the xyphoid, at maximum inspiration. By multiplying the area of the lung-fields at inspiration by this anteroposterior diameter measurement, the roentgenologic chest volume was obtained. The best correlation was obtained between the figure and the vital capacity. The formula established is: roentgenologic chest volume × 0.24 plus 1.22 equals predicted vital capacity. A good correlation was also obtained between the lung area at maximum inspiration and both vital and total pulmonary capacities.

J. E. Habbe, M.D.

PROTECTION

Tests of the Protection against Radiation and Scattered Radiation in Eighteen Modern Roentgen Departments. Gerhard Heise. Strahlentherapie, 1935, **53,** 574–594.

The author carried out a series of ionization measure-

ments using a Küstner instrument with large chamber in eight diagnostic, eight deep therapy roentgen departments, in two non-medical research institutes, one super-high voltage installation, and one radium institute. The tolerance dose of Mutscheller was used as basis for his comparisons; it is equivalent to 0.25 r for an 8-hour working day. In fluoroscopic rooms the dose in the neighborhood of the patient is higher than the tolerance dose; however, it can be overcome by adequate lead rubber protections. In deep therapy the scattered radiation emitted by the patient may be, particularly for large treatment areas, as high as twenty times the tolerance dose. It is necessary, therefore, to place the operator of the machine in a protected room: 22.5 mm. of lead offered sufficient protection against irradiation from 160 mg. of radium enclosed in a lead-lined safe.

ERNST A. POHLE, M.D., Ph.D.

RADIUM

Radium Therapy of Carcinoma of the Tonsils and Pillars. Angelo Santoro d'Emidio. Strahlentherapie, 1935, **53,** 658–673.

The author briefly discusses the method of Coutard and telecurietherapy in the treatment of carcinoma of the tonsils and pillars. His own technic consists of the application of five radium "tubes" containing 2 mg. each. They are introduced in the tissue at an average distance of 15 cm. (this should probably be mm.), and left *in situ* approximately eleven days. At that time there is definite edema with radio-epithelitis and considerable pain. The symptoms subside, however, after a few days, during which time the patients are on a liquid diet. A careful technic is necessary in order to avoid injury to blood vessels. The cervical glands are irradiated by means of radium applicators placed at 1.5–3 cm. distance. In closing, the author emphasizes the efficacy of the interstitial treatment method in combination with external irradiation.

ERNST A. POHLE, M.D., Ph.D.

Practical Experiences in Radium Dosimetry. I.—General Remarks. H. Holthusen. Strahlentherapie, 1935, **53,** 543–551.

II.—Our Experience with the Photometric Method of Dosage in Radium Practice. A. Hamann. Strahlentherapie, 1935, **53,** 552–573.

Although photometric methods are not reliable for roentgen dosimetry, the author of Part I has found them accurate enough in practical radium dosimetry. He briefly outlines the development of the method in his laboratory and discusses its clinical application.

In the second part of this contribution Hamann describes in detail the technical procedure of the photographic method used in the determination of radium doses. Briefly, it consists of the exposure of diagnostic Agfa films, about 6 sq. cm. in size, placed under a cube of beechwood (length of edge 5 cm.) which carried the radium applicator containing 13.3 mg. filtered through 1 mm. Pt. Standard films produced in this manner and correlated with the erythema on the skin can then be compared with films produced by exposure to other radium applicators. The test films reveal the degree of homogeneity in a treated skin area, and the determination of isodose curves for radium applicators at various distances can also be done with this method. A table shows the doses used by the author in a number of malignant tumors, with data concerning amount and type of radium applied, intensity (in r per minute), and duration of treatment.

ERNST A. POHLE, M.D., Ph.D.

THE SPINE

Six Cases of Isolated Disruption Fracture of Spinous Process of Seventh Cervical Vertebra and First Dorsal. V. Bloch. Ugesk. f. Læger, March 21, 1935, **97,** 358–360. (Reprinted by permission from British Med. Jour., June 29, 1935, p. 103 of Epitome of Current Medical Literature.)

The author has observed in his practice six instances of isolated fracture of the spinous process of the seventh cervical (three cases) or first dorsal (three cases) vertebra. All the patients were men between the ages of 25 and 40, engaged as navvies in shovelling frozen lumps of earth up into carts. The clinical picture was remarkably uniform—sudden and violent pain in the nape of the neck and between the shoulder-blades in the act of shovelling. There was tenderness on pressure over the lowest cervical or first dorsal vertebra. The x-rays showed fractures of the spinous processes in the middle or at the junction of the central with the posterior third of the bone. The loose fragment was displaced downward in its entirety or with its most posterior end. In only one case was there no dislocation. Treatment consisted of rest in bed for about three weeks. With only one exception pain was felt on return to hard work several months after the accident. In his study of the literature the author has found a conflict of opinion over the merits of excising the loose fragment of bone in those cases in which pain persists. In a case recorded by Lönnerblad the removal of the loose fragment did not banish the pain. According to another authority, bony reunion is not to be expected; there is either fibrous union, or the fragment of bone remains floating.

Subluxation of the Apophyseal Articulations with Bony Impingement as a Cause of Back Pain. Lee A. Hadley. Am. Jour. Roentgenol. and Rad. Ther., February, 1935, **33,** 209–213.

Particular consideration is given to subluxation of the apophyseal joints of the lower spine as a cause of back pain following injury. Thinning of an intervertebral disc may not be a direct cause of pain, but this symptom may be explained by (1) tension upon capsular ligaments, (2) encroachment upon size of lumen of the foramina, and (3) impingement of the ends of the articular process against the pedicle above and the lamina below. Several cases are illustrated to show the

value of oblique roentgenograms for determining the size of the foramina and the presence of impingement of the articular processes on the adjacent pedicle or lamina.

J. E. HABBE, M.D.

TUMORS (DIAGNOSIS)

Retropharyngeal Tumors. L. Natanson. Rev. de Laryngol., d'Otol. et de Rhinol., January, 1935, **56,** 51–102. (Reprinted by permission from British Med. Jour., April 6, 1935, Epitome of Current Medical Literature.)

The author has collected 52 cases of retropharyngeal tumors since the classic work of Heinatz, who submitted conclusions based on 34 cases, all he had been able to discover in fifty years. The present author's conclusion is that these growths are generally benign in nature, except in infants, when they are always malignant. As a rule they are of neurogenic etiology (neuromas or neurofibromas), arising from the cervical part of the sympathetic system. A minority are lipomatous, and a still smaller minority are primitive goiters. Very probably the tumors of nerve origin represent a local manifestation of von Recklinghausen's disease in an unusual site. Retropharyngeal tumors are often associated with symptoms of sympathetic disturbance, particularly of the complete or partial Claude Bernard-Horner syndrome. Natanson advises that in any case of doubtful diagnosis a special investigation should be made for the presence of these symptoms, and adds that an x-ray examination is often most helpful. Growths in this situation have a tendency to extend—an indication for surgical removal, particularly since they are fairly easily removable when small. The buccal route is indicated only when the tumor is situated in the mesopharynx and there is no fear of it being goiterous. In all other cases the best route is by a lateral pharyngotomy, through an external incision. Provided with a good light, and with the patient in a suitable position, it is nearly always possible for the surgeon to avoid the necessity of maxillary resection. Since these tumors are nearly always benign, it is useless to treat them with x-rays or radium, and such measures will complicate any later surgery that may be found necessary. Only obviously malignant tumors are suitable for radiotherapy.

TUMORS (THERAPY)

Report on Malignant Tumors of the Testicle. William Bloom. Strahlentherapie, 1935, **53,** 611–629.

Following a brief discussion of pathology, etiology, and diagnosis of tumors of the testicle the author analyzes 20 cases observed since 1925 at the Roentgen Institute, University of Zurich. All cases were verified histologically: 85 per cent were seminomas, 10 per cent teratomas, and 5 per cent lipomyxosarcoma. The seminoma was most radiosensitive. One case of teratoma lived a year and a half, one eight months, and the patient with lipomyxosarcoma three months. Most cases came in at a late stage of the disease, often with demonstrable metastases. Operation alone does not seem advisable; three of the author's patients who did not receive irradiation returned with huge recurrences within a year after surgical removal of the testicle. The most common sites of metastases were abdomen, lungs, and inguinal glands. The survival periods following removal of the testicle and irradiation varied from one month to 45 months in those who died, and from six to 88 months in those still alive. The technic used in these cases varied somewhat. Up to 1930 a single dose of 100 per cent H.E.D. was given, followed sometimes by additional treatments four weeks later. Since 1930 the fractional dose method or the protracted fractional dose method has been used. These cases received anywhere from 600 to 29,000 r, distributed, of course, over a number of series. Three cases were irradiated before operation.

An analysis of the entire material leads the author to the recommendation of pre-operative irradiation, followed by removal of the involved testicle with intense post-operative irradiation by the protracted fractional dose method. A special paper is appended wherein data on all observed cases are compiled. A good bibliography is given.

ERNST A. POHLE, M.D., Ph.D.

Pre-operative Irradiation of Cortical Renal Tumors. Charles A. Waters. Am. Jour. Roentgenol. and Rad. Ther., February, 1935, **33,** 149–164.

The author has been using pre-operative irradiation of cortical renal tumors since 1923, having first reported the results of the pre-operative radiation treatment of nine cases in 1933. In the present article six more cases are added, making a total of 15 reported in the literature by this author.

Pyelography is of importance in determining the usefulness of radiation as a pre-operative measure, since tumors of the hypernephroma and embryonal carcinoma type are relatively radiosensitive, while the papillary carcinomas of the renal pelvis and the malignant papillary cyst adenomas are radioresistant. It was shown in a critical study of 66 cases of renal tumors in which both microscopic and gross pathologic findings were available, that the roentgen diagnosis of cortical tumors was correct in 90 per cent and of pelvic tumors in 100 per cent of these cases. It is now a routine procedure to make pyelograms of the treated kidney after each series of treatments in order to determine the degree of shrinkage of the tumor. By these serial pyelograms the writers are able to determine by therapeutic test the radiosensitivity of the cortical tumors. While the series is admittedly small, 93.4 per cent of these cortical tumors were found radiosensitive.

A series of treatments ordinarily requires about three weeks for administration. Daily doses varying from 195 to 345 r are given, depending upon the reaction of the patient. Deep therapy is employed, using 200,000 volts with 0.5 mm. copper filtration, and a total tumor dose of from 1,600 to 3,500 r is accomplished by employing three—and sometimes four—portals of entry. In the majority of cases blood transfusions have been given following irradiation and preparatory to operation. In all but one case of this series of cortical tumors there

was prompt reduction in size, usually beginning within a few days after starting therapy and continuing for several weeks after cessation of treatment.

In some instances a second series is administered. Those cases that do not respond to the first or second series are probably so radioresistant that further therapy is contra-indicated.

Pre-operative irradiation diminishes the size of the tumor and allows more freedom of operation. In seven cases the tumor was so large that operation would have been practically impossible at the time the patient was first seen.

In addition to reduction in size of the mass, there also results an extensive fibrosis from the tumor, with thickening of the capsule which inhibits expansion of the mass. There is sclerosis of the small blood vessels and the capillaries supplying the tumor, this change being observed principally within and beneath the tumor capsule. Microscopically the cell outlines are indistinct or lost entirely, and frequently compressed between connective tissue fibers. The nuclei are smaller and lose their staining qualities. Marked hyalinization and fibrosis occur. Hyalinization, fatty degeneration, and interstitial fibrosis, which are so marked in the tumor area, are strikingly absent in the uninvolved portion of the kidney.

Operative removal is imperative and should be carried out within a few weeks after completing the first (or, if given, the second) series, depending upon the degree of shrinkage of the tumor as revealed by palpation and retrograde pyelographic studies. Regrowth of the tumor occurs, of course, if operation is delayed too long.

J. E. HABBE, M.D.

Further Observations on the Roentgen Treatment of Pituitary Tumors. George E. Pfahler and Edgar W. Spackman. Am. Jour. Roentgenol. and Rad. Ther., February, 1935, **33,** 214–226.

While the importance of x-rays both in the diagnosis and in the treatment of pituitary tumors is fairly well established and recognized, no fixed rules can be laid down as to which cases should have irradiation therapy and which should be submitted to operation. In general, best results are obtained with x-rays in the solid pituitary adenomas, the cystic adenomas and other types of tumors responding less favorably. The writers warn against prolonged roentgen therapy beyond the point of practical value or normal tissue tolerance. If in any given case the surgeon and neurologist decide that the case offers a reasonably fair chance of success by operative means, then roentgen therapy may be regarded as of second choice. There are, of course, certain cases in which the entire tumor mass cannot be removed, in which situation the entire hope of preventing regrowth depends upon irradiation.

In the series of 21 cases considered in this paper, 13 were first seen in a stage too far advanced to expect satisfactory results from any form of treatment. It has been rather exceptional to diagnose this disease in an early stage.

Concerning clinical aspects of the cases, the most universal symptom encountered was headache, 17 of the patients complaining of either generalized headache or pain in the occiput or back of the eyes. This symptom is usually quickly relieved by treatment, many patients being decidedly helped by a single application of the roentgen ray. Visual disturbances of objective character were present in 12 cases. In the early stages contraction of the fields for red before the form fields were correspondingly affected was noted. Often the fields of vision were reduced to one-third of normal or less before the patient realized that anything unusual was occurring. In the far advanced cases rapid growth, gigantism, or acromegaly was noted. Five cases showed some form of muscular weakness and four increased thirst and polyuria. Three cases were recognized on routine examination, with no objective knowledge of any of the above symptoms on the part of the patient. The typical bi-temporal hemianopsia was not encountered in as large a percentage of cases as might be expected, hence x-ray study in all cases of unexplained optic atrophy, contraction of visual fields, or papilledema is clearly indicated.

The series reported represent unselected cases encountered in hospital and private practice.

All cases amenable to roentgen treatment (as shown by expansion of visual fields) will show a favorable response by the administration of 200 per cent, 1,600 r, through the usual three portals of entry. When cases do not respond to this amount of treatment they should be considered surgical. This amount of treatment can easily be given within two months. As high as eight to ten erythema doses to each skin portal have been given in some instances, and by carefully limiting the area of the field no unfavorable result has been encountered.

Post-operative roentgen therapy is strongly urged for every case in which surgical removal of the tumor may have been incomplete.

J. E. HABBE, M.D.

Indications for Radiation Therapy of Primary Bone Tumors. Ferd. Tomanek. Strahlentherapie, 1935, **53,** 682–709.

This is a review of the literature dealing with the indications for radiation in primary bone tumors. The American literature has been covered well. The article is not suitable for abstracting.

ERNST A. POHLE, M.D., Ph.D.

ROENTGEN-RAY FILMS (IDENTIFICATION)

The Legal Aspect of Identification and Interpretation of Roentgenograms. I. S. Trostler. Am. Jour. Roentgenol. and Rad. Ther., November, 1934, **32,** 680–693.

In a review of 83 decisions emanating from the highest courts of 30 States, it was found that the legal aspect of identification and interpretation of roentgenograms varied considerably.

It is necessary to impress the courts with the facts that all roentgenograms, whether they be used in court in or clinical medicine, should be properly and unquali-

fiedly identified, and that the interpretation of all roentgenograms should be made by properly qualified medical roentgenologists and by no others.

S. M. Atkins, M.D.

THE SKIN

Radium Dosage and Technic in Benign Lesions of the Skin. Howard Morrow and Laurence R. Taussig. Am. Jour. Roentgenol. and Rad. Ther., December, 1934, **32**, 735–737.

In most benign dermatologic conditions in which radiation therapy is indicated, roentgen rays are superior to radium. The notable exceptions are the vascular birth marks. In the cavernous hemangiomas, radium is by far the best method of treatment, while in nevus vasculosus it has certain important points of superiority over any other form of treatment.

S. M. Atkins, M.D.

THE SPINE

The Prognosis of Fractures of the Vertebræ. E. Walter Hall. Am. Jour. Roentgenol. and Rad. Ther., November, 1934, **32**, 617–621.

Studying 155 consecutive cases of vertebral fractures, the conclusions were drawn that in the majority of cases, namely, those with little or no vertebral deformity, no narrowing of the discs, or with fixation by bony ankylosis, approximating 70 per cent of all vertebral body fractures, the ultimate prognosis should be good both for recovery of function and freedom from symptoms.

With the newer methods of treatment, namely, complete reduction in marked hyperextension, application of a cast in this position, and institution of physiotherapy and exercise, the percentage of freedom from symptoms should be materially increased. Fixation in the cast for from three to five months is advised by Jimeno-Vidal, and no further support after that.

Herniation of the nucleus pulposus has been overemphasized, for many instances of the condition are seen in patients who have no symptoms.

Fractures of the transverse processes are not rare and heal as readily as fractured ribs and should be treated in the same fashion—adhesive strapping and not a plaster cast. Patients should be symptom-free and able to resume normal activities in from two to three months.

S. M. Atkins, M.D.

THE STOMACH

Wrong Diagnosis in the Roentgen Diagnosis of the Stomach. Fritz Eisler. Röntgenpraxis, July, 1935, **7**, 447–455.

Too many failures in the diagnosis of gastric lesions can be attributed to wrong or lax technic (food in the stomach, neglect to take enough roentgenograms or to use a special technic). These errors are avoidable, while errors of judgment are sometimes not avoidable.

In an ulcer a niche might be present at one time and absent a few hours afterward, to be explained by a filling of the ulcer with mucus, food, or blood. Occasionally, suspicious cases, therefore, must be re-examined if one examination is negative. A niche in the cardiac portion is easy to overlook, especially in a cascade stomach. In the pyloric and prepyloric portions of the stomach, niches may not be shown due to hypersecretion or obstruction. In such cases it is advisable to refrain from a pathologic diagnosis (ulcer, cancer, scar, etc.) and to call attention only to an obstructing lesion. Marked hypertrophy of the gastric mucosa might obscure a small niche. The size of the niche cannot be used as a criterion for healing in all cases. Secretion, swelling of the mucosa, projection, etc., may be responsible for apparent changes.

Carcinomas of the fundus are often missed. The reason is poor visualization and impossibility of palpation. Examination of the stomach after artificial filling with gas is quite important in such cases. In the pyloric region it is often impossible to differentiate between ulcer and early cancer.

It is occasionally difficult to state, from a roentgenologic standpoint, if cancer is present or only hypertrophied mucosa.

Diaphragmatic hernias, especially of the hiatus type, are quite often missed because they are not looked for.

With the tremendous advance of roentgenologic diagnosis of the stomach, mistakes are still possible.

Hans W. Hefke, M.D.

SYRINGOMYELIA

Syringomyelia: Its Roentgenologic Diagnosis and Radiotherapeutic Response. E. A. Zimmer. Fortschr. a. d. Geb. d. Röntgenstrahlen, 1935, **51**, 247–260.

This paper presents a brief review of the pathology, roentgen diagnosis, and therapy of syringomyelia. Hydromyelia is separated from syringomyelia as it corresponds to hydrocephalus internus and represents congenital or acquired distention of the central canal and filling with hydropic fluid; pyo- or hematomyelia occurs. The roentgenologic and pathologic-anatomical review of cases afflicted with this disease may distinguish between atrophic and hypertrophic articular manifestations. Malignant tumors and Charcot joints may at times be confused with syringomyelia. Various surgeons have attempted improvement of the condition by opening and drainage of the cyst in the spinal cord responsible for the neurologic disturbance, with but limited results.

Radiation therapy proved beneficial in a large majority of patients subjected to this treatment. In the author's institution approximately 50 per cent of a single erythema dose is delivered to the spinal cord for therapeutic purposes. Radiation treatment of this disease should be encouraged.

H. A. Jarre, M.D.

THE TRACHEA

Tracheal Diverticulum: Observations on a Cadaver and Results of Histologic Study. Edward F. Ziegelman. Arch. Otolaryngol., April, 1935, **21,** 414–425. (Reprinted by permission from British Med. Jour., July 13, 1935, p. 7, Epitome of Current Medical Literature.)

The author discusses the literature on the rather rare condition of tracheal diverticulosis, and reports observations on a cadaver and the results of histological study. In the acquired type of this condition infection of the mucous glands of the post-tracheal wall appears to be an antecedent factor; the exciting cause is probably some increase in the intratracheal pressure of air. Such a lesion will disturb the laryngeal innervation and cause changes in the voice. It serves as a potential reservoir of infection, continually bathing the lower respiratory tract with purulent material, and endangering the lungs, in which abscess development may ensue. It has to be differentiated from an esophageal diverticulum and a tracheal retention cyst. This may be effected by a radiographic examination of the trachea after the instillation of iodine in poppy-seed oil. The treatment is the surgical removal by amputation or inversion, with any necessary regulation of the patient's occupation. The safety precaution of the two-stage technic, as used in cases of esophageal diverticulum, would seem logical, or the one-stage method with the added use of the tracheoscope might be applicable.

TUBERCULOSIS, PULMONARY

The Roentgen Manifestations of the Initial Tuberculous Infiltrate. H. Assmann. Fortschr. a. d. Geb. d. Röntgenstrahlen, 1935, **51,** 1–7.

This is a résumé of the knowledge regarding the initial tuberculous infiltrates on the basis of German, French, and American studies. Their roentgen manifestations are apparent as more or less circumscribed, at times somewhat indefinitely delineated, rounded foci or diffuse opacities of even density. Preferred sites commonly are the infraclavicular posterior area of the upper lobes and also the apices of the lower lobes, which latter locations are often and easily confused with hilar tuberculous lymph adenopathies. Extensions, particularly of diffuse infiltrations, occur predominantly in segments of poor pulmonary ventilation and slow lymphatic exchange, and at margins of lobes, especially posterior, and the lower layers of the upper apices of the lower lobes.

The fate of these initial infiltrates varies greatly—resorption in relatively short periods, induration with connective tissue proliferation and scar formation, a contiguous extension, bronchial or vascular dissemination with the well-known complications.

Pathologically, the initial infiltrate represents a bronchopneumonic focus with a tendency to central caseation. Clinically, the infection may often be masked as a febrile, influenza-like attack or else take a more insidious course.

Quite similar roentgen symptoms may be produced by various other diseases; for instance, primary and secondary tumors, abscesses and infarcts, influenza and non-tuberculous bronchopneumonias, rarely syphilis and actinomycosis. Therefore a single roentgen examination cannot give an etiologic differential diagnosis but it should reveal pathologic conditions which frequently escape observation by any other clinical method at a time when rational treatment is most hopeful. All clinical resources should be called on for diagnostic and therapeutic aid, as soon as roentgen studies have revealed a questionable lesion, and frequent roentgen re-examinations are essential.

H. A. JARRE, M.D.

Roentgenologic Differential Diagnosis of Miliary Tuberculosis. S. Scheidegger. Fortschr. a. d. Geb. d. Röntgenstrahlen, 1935, **51,** 209–214.

A case of miliary non-tuberculous bronchopneumonia, partly chronic in character, partly recent, in the presence of uremia and a hemorrhagic enterocolitis with multiple small necroses in the liver, furnished a roentgenogram somewhat similar to miliary pulmonary tuberculosis. This leads to a brief discussion of the disease processes which at times can simulate the roentgenographic appearance of miliary tuberculosis: passive congestion and edema; bronchopneumonia, especially in influenza, measles, whooping cough, and sepsis; psittacosis, lymphogranulomatosis, Niemann-Pick's disease, carcinomatosis and chorionepithelioma, pneumoconiosis, and bronchiolitis obliterans.

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Significance of Pyrexia in Chronic Pulmonary Tuberculosis. Maurice Myers. British Med. Jour., Aug. 10, 1935, **2,** 250–252.

Before the value of serial x-ray films was demonstrated in the treatment of pulmonary tuberculosis, the temperature chart occupied the most prominent place as the indicator of the activity of the disease. However, with the advent of serial x-ray examination, it was noted that it is possible for the disease to be active and spread without any disturbance of the temperature curve and, conversely, that the patient can be febrile over comparatively long periods of time without any evidence that the disease in the lung is spreading. "Nowadays, the serial x-ray examination is undoubtedly the most accurate single method of determining the progress of retrogression of the disease." However, the author believes that the temperature chart is still of great significance, especially when correlated with serial x-ray examination.

The author correlated the temperature curves with the various types of lesions as suggested by Wingfield's classification. The lesions are classified as follows: (1) the secondary lesion consisting of a local allergic reaction due to a deposit of bacilli; (2) the inter-

mediate lesion corresponding to what is known as active fibro-caseous disease; (3) the tertiary lesion, which corresponds to the healed, non-progressive intermediate lesion.

It was noted that the small "secondary" lesion about the size of a two-shilling piece may produce no symptoms. The medium-sized "secondary" lesion results in a disturbance of temperature somewhat similar to a mild attack of influenza, which may return to normal in a few days and remain normal for many weeks or months. The large "secondary" lesion has an onset somewhat more marked than the medium-sized lesion and resembles an attack of lobar pneumonia. However, the temperature returns to normal gradually by lysis after a period of about 14 days. The absence of tubercle bacilli in the sputum and the absence of the crisis distinguishes this from lobar pneumonia.

It was observed in the case of the "intermediate" lesion that the disease may be active and spreading and still give no indication on the temperature chart for the first few weeks. It is believed that temperature and clinical symptoms are noted in this condition only with the erosion of a patent bronchus and the onset of secondary infection. During the period that a patient is pyrexial, as a result of a spreading "intermediate" lesion infected with pyogenic organisms, it is still possible for a new "secondary" lesion to appear in the lungs.

While the "tertiary" lesion theoretically should not be associated with pyrexia, this is not always the case, for many patients with static lesions, who appear to be in good general health, run a constant mild pyrexia, which is considered of little significance. The increased temperature in these cases is believed due to the secondary infection in the small cavities and to alteration in the temperature control mechanism which has occurred as a result of prolonged pyrexia and toxemia.

Another temperature chart of importance is that due to "late cavitation." This may occur in a case that has had a fairly gross disease followed by massive fibrosis. In the course of a mild intercurrent respiratory tract infection, the patient may exhibit a few days of mild pyrexia followed by a marked rise in temperature associated with the expectoration of a large amount of purulent material. The temperature then falls rapidly to normal or to a state of mild pyrexia. The x-ray film in these cases shows cavitation of an old fibrosed lesion with no spread of the disease. This cavitation results from secondary infection of the old caseous material.

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VASOMOTOR DISTURBANCES

Roentgen Therapy in Vasomotor Disturbances of the Extremities. R. Gilbert and L. Babaiantz. Strahlentherapie, 1935, **53,** 455–472.

The following affections belonging to the group of vasomotor disturbances were treated by roentgen rays: intermittent claudication, paresthesia, erythromelalgia, Raynaud's disease, endarteritis obliterans, Burger's disease, trophic ulcers, and post-traumatic circulatory disturbances. It is possible to irradiate the sympathetic nervous system alone or combine it with exposures of the adrenals. Technic: Moderate voltage; filter 2–5 mm. Al for the periphery and 0.5 mm. Cu for the deeper seated sympathetic nerves; 500–800 r distributed over from 2 to 3 weeks; dose per sitting and per field, 175 r. Of the 11 cases treated, five showed excellent response and brief histories of these are appended. The remaining six either did not respond or could not be followed up or had been treated too recently to allow of the drawing of any definite conclusions. Several photographs of the lesions before and after therapy also accompany the article. As supplementary treatment, medication and diathermy may be considered.

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